

Oceanus[®]

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see p. 18 for details



Marine Education

The International Magazine of Marine Science and Policy

Volume 33, Number 3, Fall 1990

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*They that go down to the sea in ships, that do business in
great waters;*

These see the words of the Lord, and his wonders in the deep.

— Psalm 107, 23-24

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Director's Statement

The Woods Hole Oceanographic Institution was established to be an international center for ocean science. Since its early years, the Institution has hosted visiting students in many categories; especially graduate students conducting thesis research, postdoctoral scholars, and undergraduate summer student fellows. In 1967, our Charter from the Commonwealth of Massachusetts was expanded to include education, specifically authorizing us to award graduate degrees. In the 20-plus years since our Joint Program with the Massachusetts Institute of Technology was initiated, education at the master's, doctoral, and postdoctoral levels, and semester or summer research experiences for undergraduates, has become an intrinsic part of our research.

We are now finding it important to extend our educational outreach to a much broader audience. Ocean science is exciting and can spark the imaginations of school children; the oceans are vital to our economic competitiveness and national defense, as well as to global health. The results of our research have immediate relevance to major issues of the day, and we must make them known to policymakers and the public, as well as to our scientific peers. *Oceanus* itself is a major contributor to this educational process. We try to address topics that are timely and important as well as interesting.

This issue discusses both traditional and innovative programs in marine education. In our usual fashion, we make no attempt to be complete. Our interest is in giving you a feel for the range of activities and perspectives on the subject.

A handwritten signature in black ink, appearing to read 'Craig E. Dorman', with a long horizontal line extending to the right.

—Craig E. Dorman
Director, Woods Hole Oceanographic Institution

MARINE EDUCATION



Awakening Interest Early

1 Director's Statement *by Craig E. Dorman*

The Woods Hole Oceanographic Institution is extending its educational outreach to a much broader audience in an effort to better inform the public on some of today's major science issues.

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The author reports on the many marine programs in place for kindergarten through 12 youth, which include history, literature, song, and art, as well as earth, life, and physical science.



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The authors call for the oceanographic community to establish a plan to meet the education challenges facing the field. They outline five activity areas as a basis for such a plan.



Individual Graduate Project

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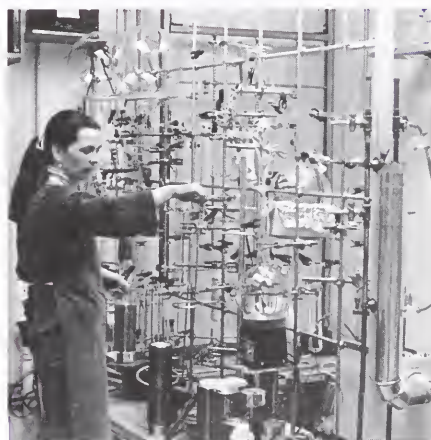
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THE COVER is a graphite drawing by Ron Bolt, a Canadian artist. It first appeared in the book *The Inner Ocean*, and was entitled "Alexander's Rag Time Boat," © 1979. Other credits appear on page 38.

The Unchanging Image of the Scientist

Children's ideas about scientists have changed little during the last 30 years. In 1957, Mead and Métraux summarized the views of about 35,000 high school students, noting consistently shared characteristics, and then a division between a positive and negative image:

Shared Image

The scientist is a man who wears a white coat and works in a laboratory. He is elderly or middle aged and wears glasses...He may be bald. He may wear a beard, may be

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Introduction

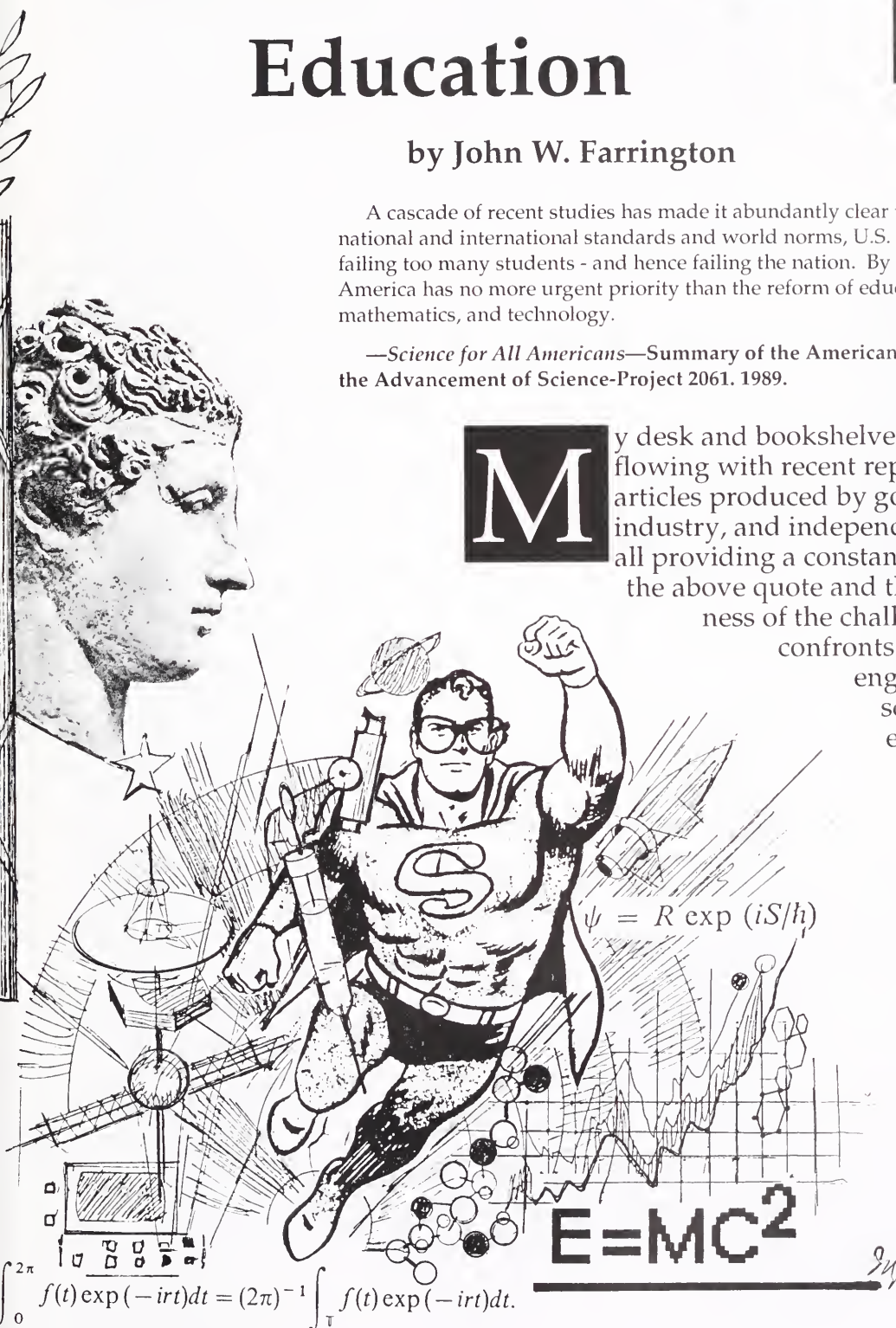
Marine Education

by John W. Farrington

A cascade of recent studies has made it abundantly clear that by both national and international standards and world norms, U.S. education is failing too many students - and hence failing the nation. By all accounts, America has no more urgent priority than the reform of education in science, mathematics, and technology.

—*Science for All Americans*—Summary of the American Association for the Advancement of Science-Project 2061. 1989.

My desk and bookshelves are overflowing with recent reports and articles produced by government, industry, and independent groups, all providing a constant reminder of the above quote and the seriousness of the challenge that confronts those of us engaged in science, mathematics, and



$$\int_0^{2\pi} f(t) \exp(-irt) dt = (2\pi)^{-1} \int_T f(t) \exp(-irt) dt.$$

$$E=MC^2$$

engineering education—indeed confronts all citizens of the United States.

These reports identify the main education challenges as being in the kindergarten through 12th grade (K-12) sector, and in undergraduate education. We need to go beyond survey and introduction courses and ensure that our young people are on intimate terms not only with scientific, mathematical, and engineering principles, but with the process by which research and discovery proceed. A key element in this advancement is the transition from new knowledge to technology, policy, and management.

How else will our youth be prepared to bring rational reasoning to such issues as global climate change, energy resources, genetic engineering, biomedical research, waste disposal problems, defense technology, space exploration, utilization of ocean resources, and as yet undreamed of challenges? Simultaneously, we must provide enhanced continuing education for our adult population. This population must be made aware of present advances in our understanding and the limits of our knowledge.

It is thus appropriate and timely for *Oceanus* to devote this issue to Marine Education. As readers will quickly realize by scanning the table of contents, this issue examines a wide range of marine education activities.

A common theme throughout this issue is the use of the oceans as a means of teaching the fundamentals of science and the scientific process. "What's been missing in science education is the, AAAH!, the excitement of doing science with your hands and your eyes," according to Robin Hogen, Executive Vice President of the Merck Co. Foundation as quoted this spring in *Fortune* magazine's special issue on *Saving Our Schools*, "We've tried to give kids the experience of discovery so they can learn by manipulating and doing."

Susan Humphris' article, "The Ocean as a Classroom: The Role of Practical Experience in Science Education" (page 46), has this as the central theme. Her statements on the use of the diversity and complexity of the ocean to introduce undergraduate students "to the excitement of discovery" address a central tenant of much of the movement toward revitalization of science education in the United States—involve the students in the process of scientific inquiry. Luther Williams eloquently supports this point when discussing careers in his article. He describes several National Science Foundation (NSF) programs aimed at providing students of all ages with a research experience.

The discovery theme is rampant in the article "Getting Kids Wet," by Valerie Chase, about marine education for grades K-12 (what a delightful, appropriate title—I was tempted to entitle this introduction "Getting Everyone Wet" after reading her article—see page 20.) The romantic allure of the sea and its part in human endeavors are delightfully woven throughout Tom Goux's "Muses

*"What's
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in the Rigging" (page 52). His infectious enthusiasm for music education and the sea reminds us that marine education should not be construed only as science and engineering, but encompasses the arts and humanities. He reminds us that interactions of people and the sea, and of the sea alone, are integral parts of the body of works in the arts and humanities.

Luther Williams, in his article, and Robert Wildman and David Ross, in their's, illuminate the substantial role of the Sea Grant program in Marine Education on a national and local basis (see page 39). They provide compelling statistics about the serious shortfalls in the numbers of scientists and engineers projected for the United States by the end of the 20th century, if current trends of decreasing interest in these careers are coupled with the demographic downtrend in numbers of college age students.

Wildman and Ross also highlight a very important problem in science and engineering education—the need for an expanded and more effective effort at attracting minorities and women to the sciences and engineering. Marine sciences and engineering are not exceptions to this general rule. Progress has been made with the increase of women ocean scientists and ocean engineers in recent years as evidenced by graduate school enrollments. However, these numbers are far below what can and should be accomplished in the 1990s and beyond. The role models are there in increasing numbers for young women thinking of a career in oceanography or ocean engineering. In addition, much needed changes in the working environment conducive to enhancing the careers of female marine scientists and engineers have or are being implemented.

Unfortunately, there has not been much progress in attracting minorities to the marine sciences, especially African-Americans and Hispanics. Often, this is ascribed to the fact that the marine sciences and engineering traditionally emerge as separate disciplines of science and engineering at the graduate education level as explained by Nowell and Hollister (page 31). It has been argued that marine sciences and engineering cannot do very much to increase minority involvement until the pool of undergraduate scientists and engineers contains a better representation of minorities.

I am pleased to report that this type of reasoning is heard less frequently and has no credibility. Ocean sciences and engineering share with all scientific and engineering disciplines the responsibility to attract minorities to sciences, mathematics, and engineering by the types of efforts described in the articles in this issue. Wildman and Ross are correct. "These small numbers of minorities in the sciences are a national shame; there are scientific opportunities for women and minorities in science, particularly in marine sciences, that should be tapped. Indeed, if the predicted shortfall is to be avoided, large numbers of women and minorities must be attracted to scientific or technical careers." Williams reports on some of the NSF programs aimed at encouraging African

*There is a
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minorities
and women in
marine
science and
engineering*

American, Hispanic, and Native American students to complete undergraduate degrees and pursue graduate degrees in all science and engineering fields.

Nowell and Hollister report on general aspects of undergraduate and graduate education in oceanography. Their article provides sound advice for students interested in a graduate education in terms of what is the best undergraduate preparation. They explain why there is less emphasis on undergraduate education in ocean sciences as a separate undergraduate major.

In other articles and reports on education, there is a general tendency to state that graduate education in the sciences and engineering in the United States is in great shape. The only problem reported seems to be the lack of sufficiently well-qualified United States students in great enough numbers. An increasing percentage of science, mathematics, and engineering graduate students in U.S. graduate schools is from other countries. The foreign students contribute effectively to research in the United States and some remain after graduate school to enhance U.S. science and technology in the great tradition of the U.S. "melting pot."

However, the demographic trend of decreasing numbers of U.S. college-age students projected during the next decade, coupled with the current trend of decreasing interest in sciences and mathematics among entering freshman, provide compelling evidence that a shortfall in qualified, much needed graduate students is occurring now and will be exacerbated in the next 10 years unless countermeasures are put in place. The major and urgent countermeasure is set forth in this quote from Wildman and Ross: "If the predicted shortfall is to be avoided, large numbers of women and minorities must be attracted to scientific and technical careers."

These are tumultuous times in science, mathematics, and engineering education in the United States, especially for K-12 and the undergraduate years. Several challenges have emerged that require simultaneous attention. **THIS IS A NATIONAL PRIORITY!** We cannot afford to gamble with the well-being of our young people in terms of providing them with less than the very best education, not only in the sciences, but in all subjects.

Our efforts should not be aimed at only an elite few of the best students in the sciences, mathematics, and engineering, but should encompass all students. Sheila Tobias, in her recent report "They're Not Dumb, They're Different. Stalking the Second Tier," published by the Research Corporation, covers this important subject. She quotes Shirley M. Malcolm, head of the Directorate for Education and Human Resources Programs of the American Association for the Advancement of Science, in February's Scientific American: "Who will do science? That depends on who is included in the talent pool. The old rules do not

*We need to
increase
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the oceans as
a means of
general
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the sciences.*



work in the new reality. It's time for a different game plan that brings new players in off the bench."

Part of the different game plan should involve an expansion of efforts to use the oceans as a means of general education in the sciences. As will be readily apparent from reading the articles in this issue, some very enthusiastic and dedicated people with innovative ideas are meeting the challenges in science, mathematics, and technology education by using the oceans as a classroom and as subject material.

Let us hope that more of our young people will "get wet" and discover the excitement of ocean sciences and the excitement and importance of science, mathematics, and engineering in general. There is no doubt that young people are ready. The key question is whether or not adults individually, in small groups, and in a national context will provide the much needed encouragement and means for our young people to realize their vast potentials.

Research on Naushon Island, part of the Elizabeth chain near Woods Hole, on the effects of an oil spill. Some of the participants were American Indians from a Southern Utah State College Upward Bound Summer program, held at WHOI during the summer of 1990.

John W. Farrington is Associate Director for Education and Dean of Graduate Studies at the Woods Hole Oceanographic Institution. A former Senior Scientist in the Chemistry Department at WHOI, and Professor at the University of Massachusetts/Boston, his background is in chemistry and chemical oceanography.

(continued from page 4)

unshaven and unkempt. He may be stooped and tired...He is surrounded by equipment: test tubes, bunsen burners, flasks and bottles, a jungle gym of blown glass tubes and weird machines with dials...He spends his days doing experiments. He pours chemicals from one test tube into another...He experiments with plants and animals, cutting them apart, injecting serum into animals...

Positive Image



He is a very intelligent man—a genius. He has long years of expensive training. He is interested in his work and takes it seriously. He works for long hours in the laboratory, sometimes day and night, going without food and sleep...He is prepared to work for years without getting results. One day he might straighten up and shout: "I've found it! I've found it!"...Through his work people will be healthier and live longer, they will have new and better products to make life easier and pleasanter at home, and our country will be protected from enemies abroad.

Negative Image



The scientist is a brain. He spends his days indoors, sitting in a laboratory, pouring things from one test tube into another. His work is uninteresting, dull, monotonous, tedious, time consuming...he may live in a cold water flat...His work may be tedious. Chemicals may explode. He may be hurt by radiation or may die. If he does medical research, he may bring home disease, or may use himself as a guinea pig, or may even accidentally kill someone...He is so involved with his work that he doesn't know what is going on in the world. He has no other interests and neglects his body for his mind...He has no social life, no other intellectual interests, no hobbies or relaxations. He bores his wife...He brings home work and also bugs and creepy things.

Based on their analysis, Mead and Métraux suggested that the mass media should emphasize the real, human rewards of science, the enjoyment of group work, and how science works. Schools, they said, should:

- emphasize participation in the classroom rather than passive learning;
- emphasize group projects;
- teach science as immediately pertinent to human values, living things, and the natural world;
- teach mathematical principles much earlier;

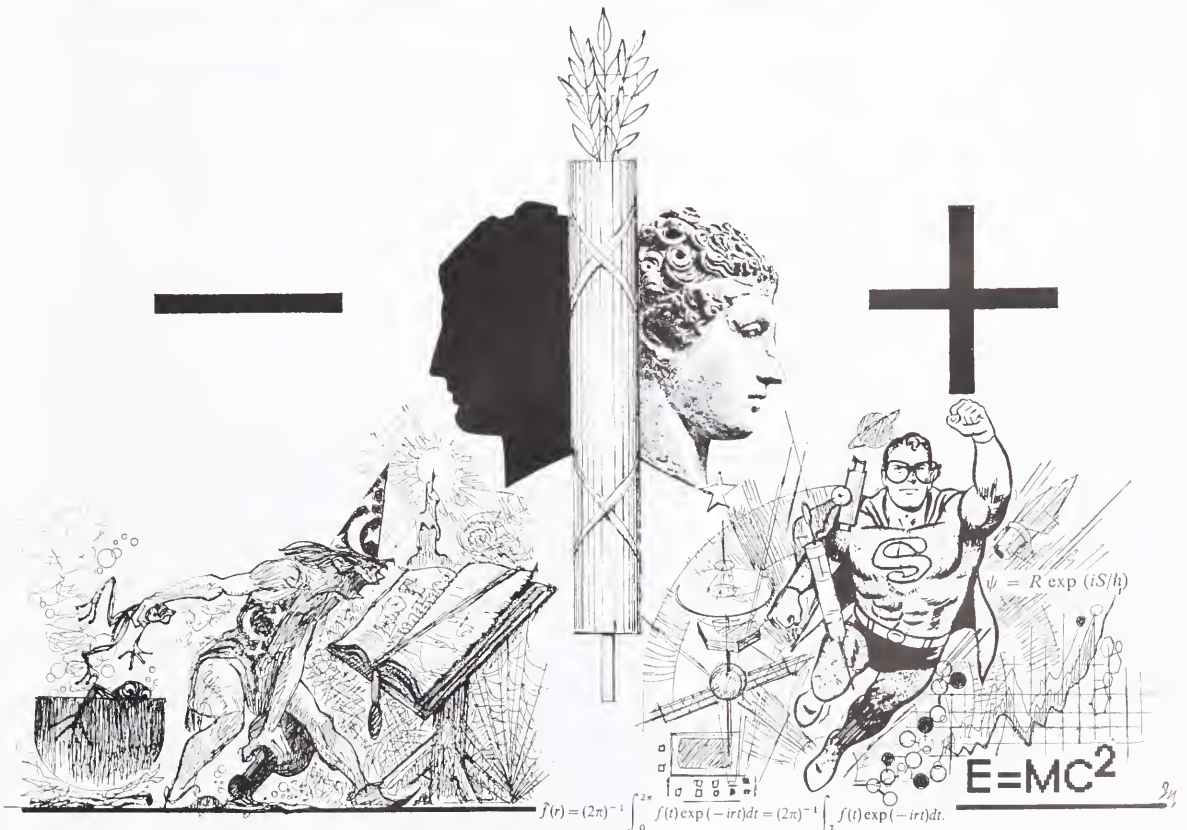


- provide teachers who enjoy and are proficient in science;
- make sure that teaching and counseling encourage girls;
- de-emphasize the rare individual geniuses of science, such as Einstein, to make science more accessible to the average child and emphasize the individual sciences as broad fields of endeavor;
- avoid talking about "Science, Scientists, and the Scientific Method" as a whole, and rather, talk about individual fields and what different methods are; and
- emphasize life sciences, humans, and other living things to make science more immediate to children.

Children of the 1980s held images of science and scientists that were essentially unchanged from those of the 1950s. In 1986, researchers at Harvard University's Educational Technology Center applied Mead and Métraux's methodology to another generation of potential scientists. They reported that:

Most responses sounded familiar: scientists are nerds and science is important but boring. The students had little inkling of the day-to-day intellectual activities of scientists, of what experiments are for, or of the social nature of the scientific enterprise.

—From *Educating Scientists and Engineers: Grade School to Grad School, 1988*, U.S. Congress, Office of Technology Assessment.



Human Resource Trends in Oceanography

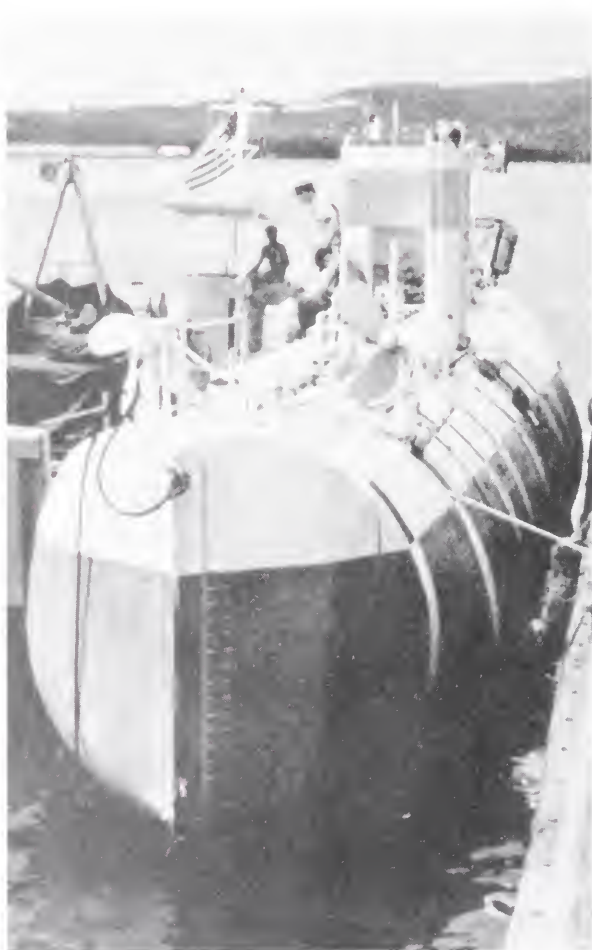
"The human mind is not withheld from penetrating
into the dark secrets of the ocean"

—Sir Charles Lyell, 1830

by Luther Williams

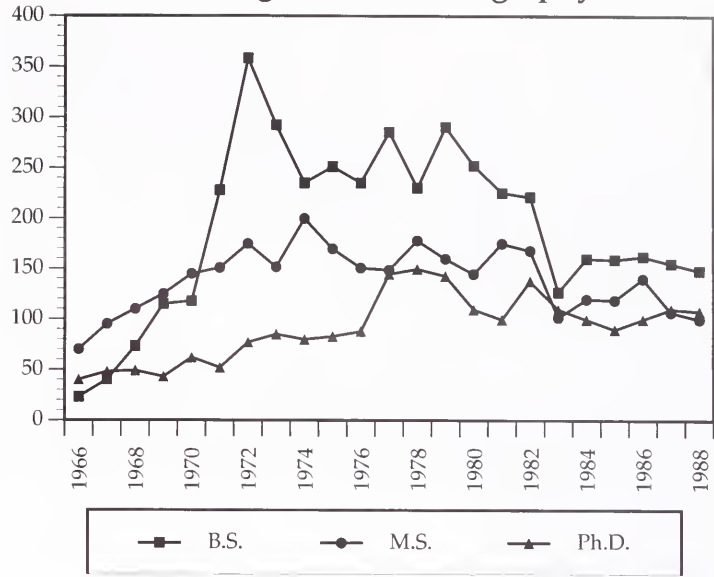
Human eyes first beheld those dark sea secrets in 1960 when Jacques Piccard and Navy Lieutenant Don Walsh descended 10,900 meters below the surface of the Pacific Ocean in the bathyscaphe *Trieste*. In that same year, Harry Hammond Hess presented his theory of seafloor spreading and the United States launched its first weather satellite, TIROS 1. Thus began a decade of unprecedented investigation and discovery in oceanography, and in science and engineering in general. A new President emboldened Americans to "explore the stars, conquer the deserts, eradicate disease, tap the ocean depths," and they did.

Throughout the 1960s, as federal and private support of research and education expanded, steadily increasing numbers of new scientists and engineers graduated from U.S. colleges and universities at all levels. Oceanography was a relatively new field, with education closely tied to research. Yet the few undergraduate programs there were



At right, the bathyscaphe Trieste prior to its record dive of 35,800 feet in the Mariana Trench off Guam, in 1960.

Degrees in Oceanography



expanded dramatically. The number of baccalaureate degrees awarded in oceanography increased to more than 350 in 1972 from less than 20 in 1966. And the increases at the master's and doctoral levels mirrored increases in the other science and engineering fields.

Throughout the decade, students pursued their fascination with science and technology. America enjoyed an unprecedented period of research vitality and economic prosperity. After 1973, however, U.S. economic growth slowed. In the sciences and engineering, the number of new graduates

dropped off. It was not until 1981 that the number of students graduating with science degrees began to increase again. And today, there are still fewer new scientists earning degrees at all levels than in the early 1970s.

As in other science fields, the number of students earning degrees in oceanography increased in the '60s and decreased in the '70s. In 1983, the number of students earning bachelor's and master's degrees in oceanography reached their lows at 128 and 103, respectively. The increases in the '80s have been variable and relatively small. Only at the doctoral level was there a steady increase in the number of new oceanographers, an increase exhibited by few other science fields.

Women, too, displayed increasing interest in oceanography. In 1966, just one woman earned a bachelor's degree in oceanography; only six earned master's degrees; none earned a Ph.D. Twenty-two years later, 83 women received degrees in oceanography, evenly divided among bachelor's, master's, and doctorates. Still, women remain underrepresented in oceanography, though no more so than in science and engineering in general.

Yet the number of minorities earning degrees in oceanography remains notably small even when compared to other science fields. Between 1975 and 1988, only two Blacks and two Native Americans received doctorates in oceanography, marine sciences, or water resources. Only 13 Hispanics earned doctorates during that period, and even Asians, who are overrepresented in most other sciences, are underrepresented in oceanography. Between 1975 and 1988, only 20 Asians earned Ph.D.s in the field, 1 percent of all doctorates awarded.

Clearly, there is a need to expand the participation in oceanog-

Women and minorities represent a vast and largely untapped reservoir of talent for oceanography.

raphy. The composition of the population is changing. Already in a number of states, more than half the student population is non-white. And by the middle of the next century, "minorities" will comprise more than 50 percent of the total U.S. population. By the end of this century, only 15 percent of the new entrants to the labor force will be white males. Women and minorities represent a vast and largely untapped reservoir of talent.

To sustain the vitality of the nation's efforts in all fields including oceanography, the research and education communities need to improve their ability to recruit and retain minority and women students. To assist researchers and educators in this task, the National Science Foundation (NSF) has initiated a number of new human resource development programs in the past decade — focused programs such as Research Opportunities for Women, Minority Research Initiation and Career Advancement Awards, Research Careers for Minority Scholars, and Assistantships for Minority High School Students.

For example, NSF is currently supporting a two-year project at the University of North Carolina at Chapel Hill that enables minority college students to learn about earth, ocean, and environmental sciences during the summer. And the Alliances for Minority Participation program, begun this year, will encourage Black, Hispanic, and Native American undergraduates to complete their baccalaureate degrees and pursue graduate studies in all science and engineering fields. This program promotes alliances both among program participants and sponsors — minority and majority 2- and 4-year colleges and universities, school administrators, other federal agencies, industry, and private foundations.

Yet, our focused human resource and education programs are only one way in which NSF influences students' decisions regarding research careers. Employment opportunities and prospects are powerful incentives for students choosing fields of study. For those considering science, the level of public and private support for research is crucially important.

Uncertainties about federal research funding can discourage students from pursuing studies in science. In oceanography, especially, this is an important concern. Research and development (R&D) are the primary work activities of most oceanographers. Sixty percent of all those employed are involved in R&D; more than half engaged in basic research. By contrast, only about 20 percent of all other employed scientists are involved in R&D, and only about a quarter of those are engaged in basic research.

Employment opportunities for oceanographers are increasingly concentrated in colleges, universities, and federal facilities. Only about 15 percent of all oceanographers were employed by industry in 1988 compared to more than 70 percent a decade earlier. In 1988, more than 40 percent of all oceanographers were employed at

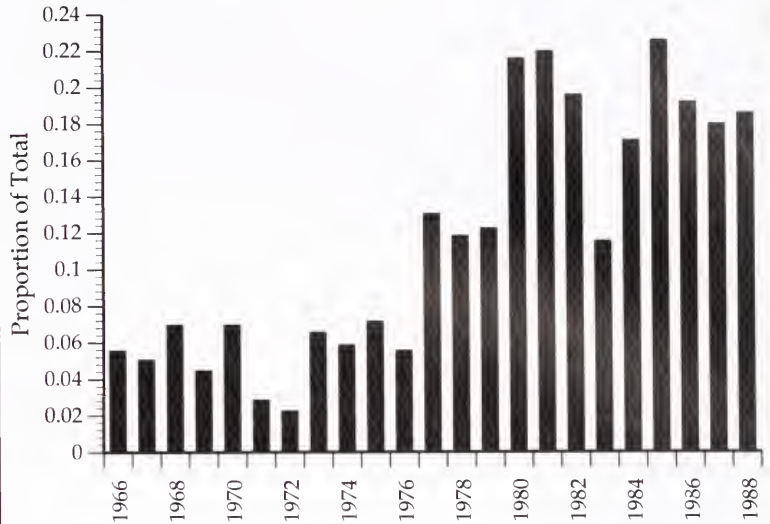
academic institutions; 25 percent were federally employed. By contrast, only about 30 percent of all scientists were employed in the academic and federal sectors combined. Oceanography, more than other fields, relies on federal academic research funding to sustain its vitality and progress.

Moreover, NSF is the primary source of basic research funding in oceanography, providing almost 70 percent of the federal funding. President Bush's plan to double the National Science Foundation budget by 1993, along with a 5-year NSF budget authorization enacted by Congress, is a positive step toward easing some uncertainties about research careers. Steady federal support of academic R&D does more than simply fund projects; it helps create an environment that attracts talented students to research careers.

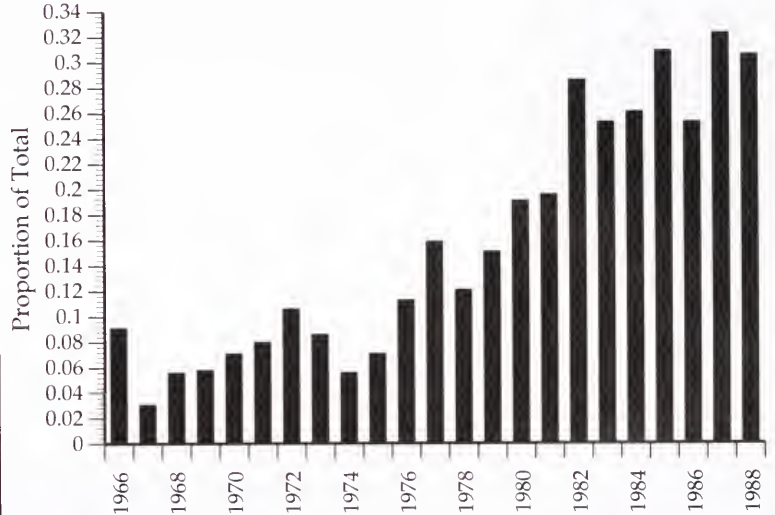
Nonetheless, the nation is unlikely to resume the R&D support pattern of the 1960s. Between 1953 and 1969, real R&D expenditures in the United States, public and private combined, increased from \$19.7 billion a year to \$64.7 billion a year (in 1982 dollars), growing at an average rate of almost 8 percent a year. Since that time, expenditures have increased to \$132

Women in Oceanography

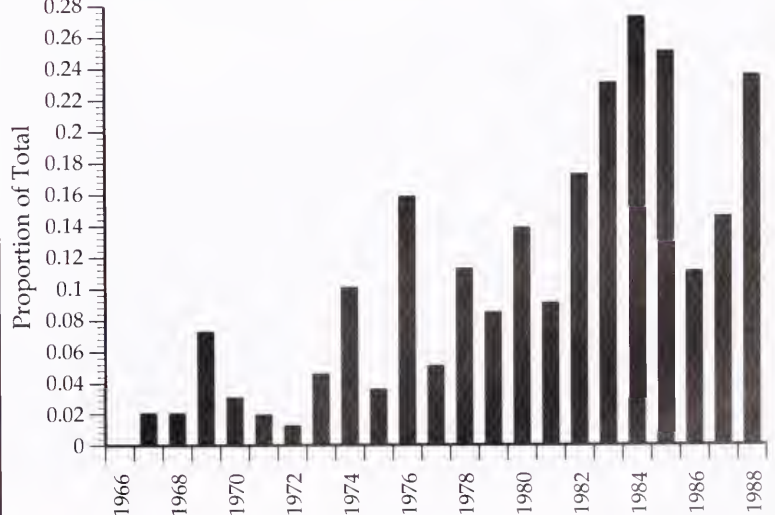
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Master's Degrees



Doctorate Degrees



*Nonmonetary
benefits far
outweigh
economic
reasons for
pursuing
careers in
science and
engineering.*

billion (\$105 billion in 1982 dollars), but the average rate of real growth has been less than 3 percent a year. Constraints on the federal budget and increased commercial competition make dramatic increases in R&D unlikely.

The economic incentives that helped draw students into science and engineering during the 1960s are not likely to be duplicated in the 1990s. Therefore, we must look elsewhere for ways to attract students to these fields. Where should we look?

Most people pursue research careers in science and engineering for very personal reasons — curiosity, the intellectual challenge, “because it seemed the most fun, because I’m good at it!” Real compensation comes from their day-to-day experiences. Nonmonetary benefits — the freedom, the intellectual challenge, the thrill of discovery, and the chance to make a lasting contribution to knowledge and to society — far outweigh economic considerations.

These benefits are best realized firsthand. Involving more students, especially undergraduates, in real research is a good place to start. Students come to understand the practice of science and engineering by experiencing it in partnership with a faculty member or as part of a group. Research experience helps undergraduates assess their strengths and better choose their career goals.

NSF has initiated a number of programs to encourage grantees to include undergraduates in their research. Supplemental funds are available to support undergraduate researchers on individual grants, and undergraduates participate in the activities of NSF-sponsored Science and Technology Centers and Engineering Research Centers.

In addition, NSF has a number of new programs designed to strengthen research opportunities for both faculty and students at undergraduate institutions. For example, this year NSF is sponsoring an “Oceanography Short Course for Instructors of Undergraduate Marine Sciences” involving 2- and 4-year college faculty in activities at the University of San Diego, Scripps Institution of Oceanography, and Grossmont Community College.

Still, many students make career decisions before they even enter college. Therefore, NSF has extended its support for mathematics and science education at the precollege level. The National Science Foundation is the primary source of federal funding in this area, comprising 45 percent of the national budget. Moreover, education and human resources are the fastest growing components of NSF’s budget, increasing more than 260 percent in the last five years. In fiscal year 1991, NSF plans to spend more than \$460 million on these programs.

Our approach is to address the process of education and human resource development as a continuum starting at the elementary and secondary levels, continuing on through the undergraduate and graduate levels and beyond. Each level presents different needs

and unique opportunities. The transitions between levels also are important and they require attention.

For example, the Young Scholars Program, initiated in 1988, is designed to expose students in grades 8 through 12 to careers in science and engineering by letting them work with researchers. For example, this December an 18-year-old from Douglaston, New York, will study the physiological ecology of adult and larval krill in Antarctica with two senior marine scientists from the University of California, Santa Barbara. Another Young Scholar from Scott, Louisiana, will study the antarctic ice sheet with a team from the Woods Hole Oceanographic Institution.

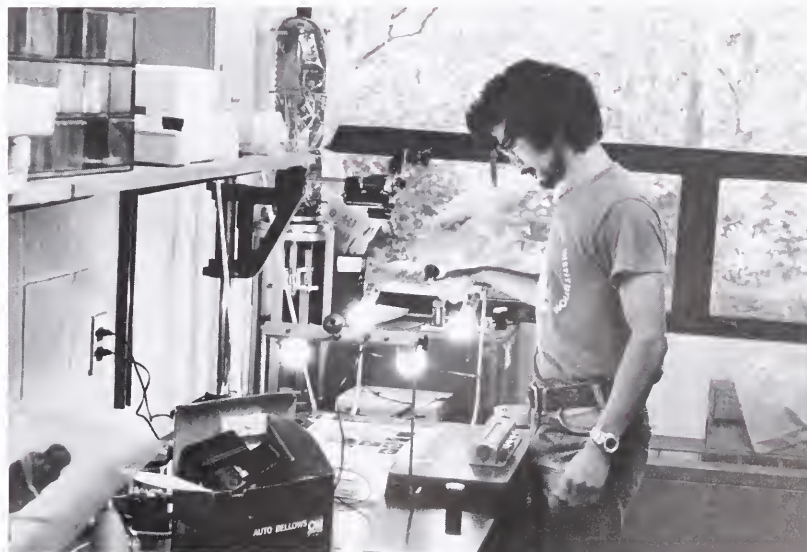
Faculties at universities and colleges, with NSF funding, also are helping to improve classroom instruction of mathematics and science at the precollege level. Programs to develop substantive and hands-on curricula and to enhance teachers' competencies in grade school and high school mathematics and science are an important part of NSF's activities. Across the country, scientists and engineers at colleges and universities and at the national laboratories, are developing similar projects with NSF support to help precollege science and math teachers better prepare and inspire their students. Moreover, NSF supports an array of informal education projects at a diverse collection of institutional sites.

NSF's new State-wide Systemic Initiative is the next logical step in this process. It's designed to support wholesale reforms in mathematics and science education at the state level by supporting the work of state officials, starting with the governor. This new initiative will augment the NSF-



The young woman (above) is preparing salt marsh samples for a spider study as part of a minority trainee program at the Woods Hole Oceanographic Institution (WHOI).

Foreign scientists, like this Japanese researcher (below), often conduct their training in WHOI's Joint Program with MIT.



supported teacher training and curriculum development projects that are already yielding positive results.

We are lucky that so many bright high school students show an interest in science and engineering. According to the Educational Testing Service, mean SAT scores for 1988 examinees planning to major in math, science, or engineering were 18 points higher than the population mean Verbal score, and 31 points higher than the mean Math score.

The challenge is to make sure that economic conditions do not discourage these students from pursuing that interest. We must let them know and experience the rich personal rewards and satisfactions of participating in research and development.

The 1990s offer opportunities for scientific and technological breakthroughs more far-reaching than those in the 1960s. Exploiting those opportunities will require well-trained and dedicated researchers in oceanography and other fields. Sustained basic research funding, improved mathematics and science education, and increased efforts to attract and retain women and minorities in research careers are crucial steps toward making today's possibilities tomorrow's realities.

Luther Williams is the Assistant Director for Education and Human Resources at the National Science Foundation, Washington, DC.

Oceanus Wins 2 "Ozzie" Awards

From a field of more than 1,300 magazines, *Oceanus* has been awarded the 1990 Gold Award (first place) given by *Magazine Design & Production* for Best Redesign of a magazine in the educational category. The award was given for the Spring issue on the Mediterranean, Vol. 33, No. 1. *Oceanus* was also awarded a Bronze Award (third place) in the Best Cover category for the Pacific issue, Winter 1989/90, Vol. 32, No. 4.

Magazine Design & Production is a monthly publication of South Wind Publishers in Kansas. The competition was open to all magazines published in the United States and Canada. One of the principal judges in the competition was Marjorie Spiegelman, an award-winning designer from San Francisco who holds a graduate degree in graphic design from the Yale School of Art and Architecture. She was the principal designer of *MacWorld*, *Publish!*, and *PC World*.

The principal staff of *Oceanus* during the period of the awards included Paul R. Ryan, editor and designer, T. M. Hawley, assistant editor and production coordinator, Sara Ellis, editorial assistant, and Robert Bragdon, advertising coordinator. Paul E. Oberlander, of OberGraphics, was the artist who conceived and created the award-winning cover. Nineteen-ninety was the first year that *Oceanus* had entered the annual competitions.

— Ed.



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Getting Kids

A Sea Grant Education Specialist (above) discusses marine adaptations with North Carolina school children. A young man (middle) aboard a Minnesota research vessel focuses on an algae specimen. With a smile as wide as the reach of a starfish, a young girl (below) shares her delight with a friend.





Kids talk to the animals in the Great Lakes Sea Grant Network. In this instance, "Gulliver," a mechanical gull, talks back, captivating his young listener with a humorous discourse on the serious subject of the environment.

*Marine
Education
for grades
K-12*

Wet



by Valerie Chase

A parent in Reno, Nevada, enters his child's classroom expecting to see rows of desks facing a teacher's desk and chalkboard only to encounter a huge shark cruising the edges of a giant kelp forest alive with colorful fish and invertebrates. Has he been magically transported to the coast of California? No, it is "Ocean Week."

The entire school has been transformed into marine

Marine education in K-12 includes maritime history, literature, song, and art, as well as earth, life, and physical science.

habitats, created by students using Project OCEAN (Oceanic Classroom Education And Networking), a curriculum from the Ocean Alliance. This is just one of dozens of innovative programs in marine education available for classroom teachers. An unexpected outcome of this particular schoolwide project is a reduction in absenteeism, vandalism, and social problems.

Marine education in grades K-12 is creative and fun. It also seeks to motivate a sense of stewardship and caring. It encompasses subjects as varied as maritime history, literature, song, and art, as well as earth, life, and physical science. Marine education has always been interdisciplinary, anticipating a current trend in curriculum development.

The National Marine Educators Association (NMEA) and its 15 chapters have facilitated an exchange of ideas and information by bringing informal and formal marine educators together at annual conferences and through its publications, *Current*, the *Journal of Marine Education*, and *NMEA news*.

Television has created a nationwide interest in the oceans, and marine educators have put this medium to work in classrooms across North America, not just along the coasts. One way that marine education reaches precollege students is through the development of new curricula. The National Sea Grant Program is one excellent source (see page 39). There are many others. Several curricula are designed for formal adoption as regular science curricula, teaching basic principles while studying the marine environment.

"Marine Science Project FOR SEA" is a comprehensive marine science curriculum for grades K-12 developed by the Marine Science Center in Poulsbo, Washington. It is distributed nationwide through the National Diffusion Network of the U.S. Department of Education in a program that includes teacher training. A smaller program with national distribution is the marine and aquatic science curriculum "Living in Water" from the National Aquarium in Baltimore, for upper-elementary to middle school children.

At the high school level, oceanography texts and materials from the Hawaii Marine Science Studies program teach about "The Fluid Earth." A unifying feature of each of these curricula is the emphasis on hands-on experimentation by students.

An alternative approach is to create enrichment activities that supplement regular classroom curricula. For example, with Project OCEAN an entire school takes a week off regular topics to study oceans. Project WILD, a nationwide program of environmental conservation education, recently introduced "Project WILD Aquatic," which includes activities in marine education.

Many marine education curricula have been developed and disseminated by informal educators or school districts. One exception is "*Voyage of the Mimi*," a highly interdisciplinary upper-

elementary to middle school curriculum. It was originated by Bank Street College located in New York City, but has been distributed by commercial publishers. It includes computer software and video tapes and follows the travels of scientists and students on a sailing whale research ship. *Mini* is often supplemented by the use of additional content and hands-on marine science materials when it is adopted as science curriculum.

A second major source of marine education for students is through visits to informal educational organizations, such as aquariums, zoological parks, nature and environmental education centers, museums, and marine field stations. There also are a number of floating field stations, such as the *Clearwater*, a sloop on the Hudson River, or the Chesapeake Bay Foundation's workboats and canoes. Programs range from 45-minute classes to residential experiences.

Instruction by specialists in marine science or maritime history is a special feature of informal education. Institutions frequently provide extensive preactivities for classroom use and teacher training programs to enhance the impact of the visit. For example, Monterey Bay Aquarium sponsors teacher training programs each summer and does cooperative teacher training with the adjacent Hopkins Marine Station of Stanford University.

Improvement of K-12 marine education is the ultimate goal of many programs aimed at teachers, as well as students. In addition to courses from informal education organizations, marine science training for elementary and secondary teachers also is provided by a number of colleges and universities, particularly those along coastlines, including the Great Lakes. These courses are often supported by funding from the National Science Foundation (NSF), Sea Grant, the U.S. Geological Survey (USGS), and the National Oceanographic and Atmospheric Administration (NOAA).

One of the most exciting aspects of many courses is a strong component of field work in the marine environment. One NOAA-sponsored program at the Marine Resources Development Foundation in Florida even includes an overnight stay in an underwater habitat. Program announcements for these courses may be found in the National Science Teachers Association *NSTA Reports!* and in the summer and academic year opportunities issues of the *NMEA News*.



From their study of the anatomy of marine organisms, students begin to discover how much of our world is influenced by the oceans.



A very strong conservation message is included in most marine education programs and curricula.

The U.S. Fish and Wildlife Service (USFWS) also is becoming involved with marine education through its funding of aquatic resource education programs with the taxes collected on boat gas and imported fishing tackle. While the initial emphasis was on freshwater environments, marine education also is receiving attention in coastal states. The programs are actually run by state departments of fish and game or natural resources.

Additional help for marine education comes from a wide variety of federal agencies that support research on marine environments, organisms, or problems. These include the Environmental Protection Agency (EPA), federal marine and estuarine sanctuaries (NOAA), or coastal wildlife refuges (USFWS), as well as similar state agencies. A welcome trend in marine education is action-oriented projects for students. During "Coastweek" in the fall, many schools help with beach cleanup programs coordinated nationwide by the Center for Marine Conservation. In addition to cleaner beaches, the data cards filled out at beach sweeps help identify specific sources of marine debris.

Other action projects include planting forest buffer strips along estuarine shores, water-quality monitoring programs that send data to marine labs or government agencies, wetland restoration, planting beach grasses or submerged vegetation, and wetland reconstruction. Many students are choosing science fair projects with a marine theme. In addition to regular science fair competition, these projects may be featured in statewide high school marine science symposia, often sponsored by marine laboratories and marine education organizations. The Massachusetts Marine Educators Association recently held its seventh high school marine studies symposium.

Another trend in marine education is toward a more holistic approach to related ecosystems. Watersheds, rivers, estuaries, and the continental shelf are now viewed and studied as a continuum. There is no longer the perception that the marine environment begins at the shore, but rather the understanding that what happens on the land is critical to coastal marine environments.

In marine education, scientific information is frequently accompanied by social studies that examine the historical and political situation in which protection and management operate. Since even food chains in the open ocean can be radically altered by fishing practices available with modern technology, international cooperation in management is necessary. In recognition of threats to marine organisms and ecosystems, a very strong conservation message is included in most marine education programs and curricula.

Cooperative programs among informal educators, government agencies, school systems, and funders also are becoming common. Information and materials may be shared across geographic boundaries in programs, such as the NSF-funded cooperative program



Bridget Sage checks her plankton net for aquatic specimens. Her Lake Superior group uses a fluorescent tracing dye to observe how lake currents transport material along the shoreline.

between the Ocean Alliance's Project OCEAN, based in San Francisco, and the University of Texas Marine Laboratory, which will bring Ocean Week to Texas and includes a strong English/Spanish bilingual component.

Alternately, many agencies may cooperate in a regional project, such as two elementary school publications on the Chesapeake Bay: *Bay BC's* and *The Changing Chesapeake*. Started as a project of the National Aquarium in Baltimore funded by Maryland's Chesapeake Bay Trust, the project grew to include the USFWS, EPA, and private funding, while Virginia's Council on the Environment, and the Alliance for the Chesapeake Bay helped with distribution.

One area in which marine education needs constant updating is in career information for secondary students. Career options change with time, with changes in concerns, and the introduction of new technology. The range of options in marine careers is greater than, and very different from, what students perceive from television. High school counselors need information on the correct preparation required for a variety of marine careers. One useful source of information is *Opportunities in Marine and Maritime Careers* (second edition) by W. R. Heitzmann.

In short, K-12 marine education is alive and well, with an expanding number of educators from both the classroom and informal education working cooperatively to improve students' understanding of the ocean and its inhabitants.

Valerie Chase was President of the National Marine Educators Association from 1989 to 1990. She is Staff Biologist at the National Aquarium in Baltimore, Maryland.

To receive a list of contacts and addresses for groups mentioned in this article, send a stamped, self-addressed envelope to Valerie Chase, National Aquarium in Baltimore, Pier 3, 501 E. Pratt St., Baltimore, MD 21202-3194.

Editorial

A Proposal to Meet Education Challenges

by Arthur R. M. Nowell
and Charles D. Hollister

The awful truth is that no scientific discipline will ever again be fully funded.

—Eric Bloch, Director, National Science Foundation

I think George would agree with investor Warren Buffett, who says that long-range planning has extreme limitations...What really counts are the day to day things. If you do well in the short run, the long run will take care of itself.

—William Bush on brother George

Social leaders and senior government administrators bemoan the absence of minorities and women in the sciences and decry the declining interest in science in the student population as a whole. But we are equally assured by them that the incentives that we know work to attract all students to science are not going to be available in the future. The federal government will not have the funds (see Bloch's statement above, and the article by Williams on page 12) to provide the economic incentives that worked in the 1960s.

Such a bleak view belies the opportunities that can exist if the ocean sciences act in a unified manner in cooperation with the federal agencies and equally important, if the federal agencies are willing to take risks

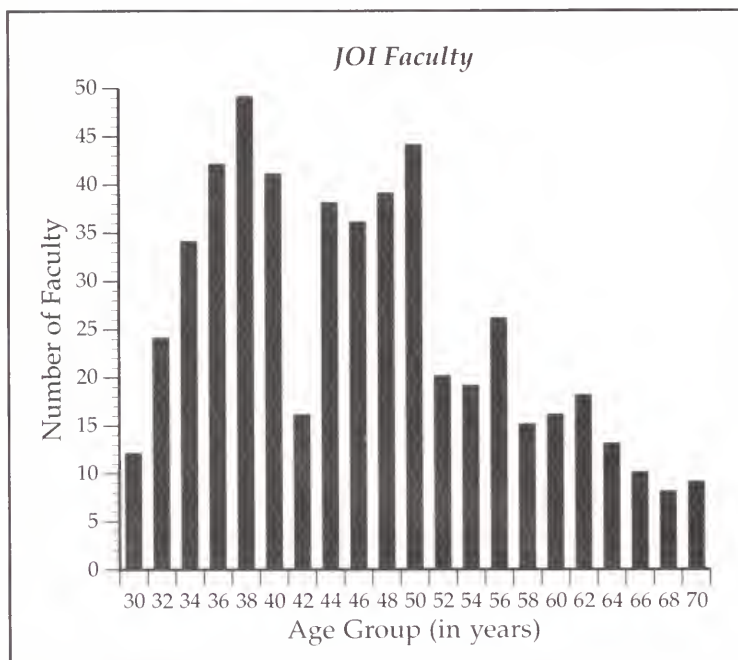
on new strategies. The dramatic budget increases for the Science and Engineering Education Directorate (SEE) at the National Science Foundation (NSF) is tribute to the concern that the members of Congress exhibit with respect to education. The question to address is how can such increased resources even within one agency be used wisely, and targeted to bring research and education closer together.

There are three key elements to addressing the education needs of the 1990s. First, we must recognize that "science education" must be broken up into workable units and that to address education uniformly in all of the sciences is to cloud the issue. We must address the problems of each field of science and tie

education and human resource issues together for the individual field, recognizing that each science may play a different role in education for different age groups of students. For example in oceanography, we do not face a retirement crisis in the 1990s as faced by some other sciences; we face the opposite problem of a young field with little prospect of major employment opportunities for the under-represented groups that we have attracted into the field in the last 10 years.

Second, the importance of peer review in selection of science must be maintained and enhanced, especially in the

more mission-oriented agencies. The coordination of federal research on Global Change through the Council on Earth and Environmental Sciences is hailed by Alan Bromley, Presidential Science Advisor, as the right way to focus our national efforts in research on global change. Yet cynics might argue that the focus of the research efforts is being blunted and, like the Hubble telescope, the focus is being lost because individual agencies are herding into the global change programs their sacred cows, and not exposing these efforts to outside peer review. Is it appropriate to leave to federal managers the determination of scientific priorities on an issue as important as global change? We emphasize this point because Bromley has suggested that a similar federal coordinating council on education be appointed next year.



The third element is that education and research must be more closely tied together. The separation of education and human resource issues from research is detrimental to both aspects of our national competitiveness; within NSF, competition between SEE and the research directorates personifies the issue. There is a need to restructure this area so that education is tied to the individual sciences; for oceanography, we put forward a draft plan for how this could be achieved.

We have tended in this country to focus on a relatively short range. But one of the functions of this office clearly is to back off and take a longer strategic look.

—Alan Bromley, Presidential Science Advisor

We propose that to tie education and research together in ocean sciences there already exist some sterling examples of recent success. The Office of Naval Research (ONR) during the last five years has initiated three programs that strike to the core of the problem in oceanography.

First, ONR initiated a Secretary of the Navy Fellowship program. It is clear that in the 1960s the rise in interest in graduate science was supported (or led) by the availability of fellowships. The dramatic decline in the availability of such fellowships from NSF has contributed to the decline in numbers of science students. Re-programming monies within the existing SEE budget at NSF to increase significantly the number of such fellowships would have an immediate and beneficial effect. The administration of such fellowships could be handled by the science directorates at NSF so that the important ties between research and education are strengthened.

The second program ONR initiated was the Ocean Science Educator Award, which created new post-doctoral positions and allied these positions with the best researchers and educators in the field. The availability of post-doctoral fellowships in science in the United States is very poor in comparison to their availability in the health sciences. The National Institutes of Health has approximately one post-doctoral fellowship for every two graduates it supports as students. The ratio in the sciences and engineering is approximately 1-to-10. In ocean sciences, ONR recognized this problem and created more post-doctoral positions allied with the best teachers. Third, ONR introduced a small program to bring college faculty from small liberal arts schools and from historically black colleges and minority institutions to spend a week at several major research universities and institutions. These faculty members learn about new research and can pass onto their students better scientific literacy, not only about the science itself, but also what career alternatives and job opportunities exist in oceanography.

Each science must develop its own plan to attract the best and the brightest.

We conclude that these successful examples could be expanded and readily applied to the NSF SEE directorate so that education at the graduate and post-doctoral level is overseen by the scientists and administered by the science directorates at NSF. Reprogramming monies from within SEE could provide the resources to address the education issues within the field of oceanography. Other sciences face different human resource problems, so it is clear that each science must develop its own plan to attract and retain the best and the brightest.

A crucial ingredient for success is the need for the oceanographic community itself to live up to its responsibilities as an educational entity. A subset of the oceanographic academic community must develop a consensus plan on the educational responsibilities, needs, and opportunities for oceanography. This plan could be provided as the basis for planning by a coordinating council so that long-range programs of support are not isolated in differing agencies, or missing.

As a basis for such a plan we outline five areas in which such a program could make a significant contribution.

The five areas are 1) elementary and secondary school level, specifically in teacher preparation and instructional materials development where there is presently a dearth of up-to-date, expertly presented, scholarly material; 2) in informal education, especially the use of telepresence to involve young persons in the excitement of oceanographic discovery; 3) in undergraduate programs, especially in supporting undergraduates to spend part of their time working in research laboratories, and in educating humanities students as part of their science requirements; 4) in graduate programs, especially in enhancing support for students and pairing outstanding teachers and researchers with the best students; and 5) at the professional level, addressing the challenge of retaining recent doctorates in the field of oceanography. This last area is one of deep concern as the field of oceanography is very young, and the average age of the faculty is only 43. This means that during the next decade there will be relatively few retirements and thus little change in the demography of the practicing field. Given the changing demography of the undergraduate and graduate populations, it is critical that innovative mechanisms to retain new doctorates in oceanography be developed. If not, we will lose some of the under-represented groups such as women and Asian Americans.

We cannot in this editorial detail all the plans for the five areas, but suffice to say there are real opportunities to develop new textbooks, new source material appropriate for the young reader, new reference material for the science teacher. There are ample opportunities to capture the excitement of youngsters about the ocean in conjunction with such entities as the Jason Foundation.

If in the next five years we do not face the challenges of retaining women and minorities in the field, of exciting young people about the ocean, and of educating the public on the role of the oceans in national security, waste management, and global change, we will indeed cede the future to other nations.

Undergraduate and Graduate Education



in Oceanography

by Arthur R. M. Nowell
and Charles D. Hollister

The education of a practicing oceanographer can begin at the undergraduate level, or even be deferred as late as a post-doctoral appointment. Because oceanography is a young science in comparison to biology, geology, zoology, and even meteorology, many who work in the field today received their formal academic training in a wide variety

John Teal (above), a Senior Scientist at the Woods Hole Oceanographic Institution, describes a cruise trawl sample to a biology student.

An undergraduate degree in the field of oceanography is rare because few colleges offer such specialization.

of other sciences, entering the discipline only after completing formal degree training. But during the last 30 years, there has been a burgeoning of universities and research institutions offering graduate degree programs in oceanography, and even some that offer undergraduate degrees in the subject.

In the last 10 years, most people entering the field of oceanography have obtained a degree in one of its subfields (geological, physical, chemical, and biological oceanography). But while there are many graduate programs in oceanography, there are relatively few undergraduate degree programs. However, the opportunity to learn about oceanography at a university does not mean one has to get a degree in the subject.

For many undergraduates, the best opportunity to learn about the ocean occurs in the survey courses offered at the introductory level. Such descriptive courses, which often fulfill university science distribution requirements for humanities and arts students, do not require the mathematics and physics background needed for virtually all advanced courses, but they do offer students a chance to learn about the interplay of how the waters of the ocean are formed and move around the planet from a biological, chemical, and physical point of view.

An undergraduate degree in oceanography is rare in the field because very few universities offer such a specialization. Although many universities and colleges offer bachelor's degrees in marine biology, such a specialization is a very small component of the overall field. An undergraduate degree in oceanography covers the physics of the ocean, namely how the currents, tides, and turbulence affect the movement of the stratified waters of the ocean; the chemistry of seawater and the importance of nutrients to the development of marine life; the history of the formation of the oceans, the generation of new oceanic crust at mid-ocean ridges, and the transport of sediments from the land around the seafloor. Such breadth of coverage, mostly descriptive, however, can only be achieved at the sacrifice of in-depth specifics. Thus an oceanography undergraduate degree is often described as a "liberal science major."

The value of the oceanography undergraduate degree rests less in preparation for graduate study, and more on the fact that the graduate has been exposed to the important interactions between the physical environment and the biological consequences of perturbations. Unlike botany or zoology, for example, where the animal or plant becomes the entire focus, a degree in oceanography lets the student understand that it is the interaction between the physical environment and the organism that is important, and that rarely can one isolate a single species for special consideration without making very dangerous assumptions about the consequent effects of one's actions.

Most undergraduates in oceanography continue in the field on

graduation—most often working for the growing number of environmental and waste management companies, public interest groups, or state and federal regulatory agencies.

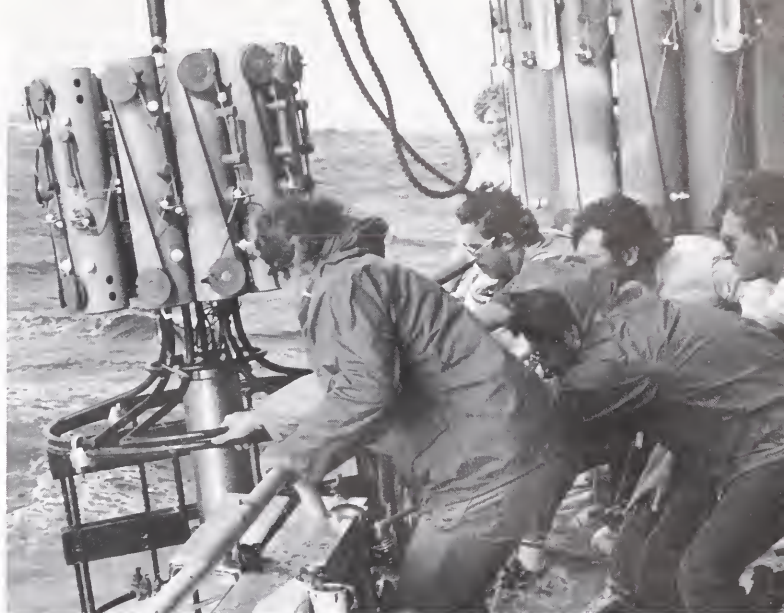
There are more than 60 institutions in the country that offer doctoral degrees in oceanography, but of these, just 10 dominate the field of “blue water” oceanography—that is, the field of ocean science that extends beyond coastal or estuarine studies and incorporates open ocean research. These 10 schools, known as Joint Oceanographic Institutions (JOI),* not only grant the overwhelming majority of doctoral degrees in the United States, but also are the nation’s largest oceanographic research centers.

The obvious tie between graduate education and research is nowhere more clear than in the work conducted aboard a research vessel or on an open ocean cruise. The scientific party usually comprises approximately six professors and scientists, 10 technicians with engineering degrees or master’s degrees in oceanography, and 10 students. The cruise most often contributes a key component to various doctoral and some master’s theses.

Many students in oceanography not only get to design a field study and collect data, they also confront the challenge of trying to interpret the information that comes back. Thus, oceanography students are neither laboratory bound, nor slaves to theory. The field offers each student the challenge of identifying a problem and deciding what area will yield the most important results first — theory, laboratory observation, or field data collection.

The field of oceanography can be compared to a small town, even though the centers of study are widely distributed along the nation’s coastlines. With approximately 500 faculty and 1,000 students at the 10 JOI schools, virtually everyone is known to one another. Thus, the best and brightest doctoral students are known throughout the community well before they graduate.

In describing the size, characteristics, and changes that have occurred to the student oceanographic population during the last 10 years, our observations are based on data collected from the 10 JOI schools. Although it represents only 10 of the 60 schools, these 10 produce 85 percent of the Ph.D.’s in ocean sciences. They also carry out



In the roil and roll of the sea, scientists (above) launch a rosette conductivity, temperature, and depth sampler (CTD) during a warm core ring study.

Kim Warner (below), a WHOI summer student fellow, conducts lab research.



*JOI Members: University of Hawaii at Manoa; Scripps Institution of Oceanography, La Jolla, CA; Lamont-Doherty Geological Observatory of Columbia University; Texas A&M University; University of Miami; University of Texas-Institute for Geophysics; Oregon State University; University of Washington/Seattle; University of Rhode Island/Kingston; Woods Hole Oceanographic Institution

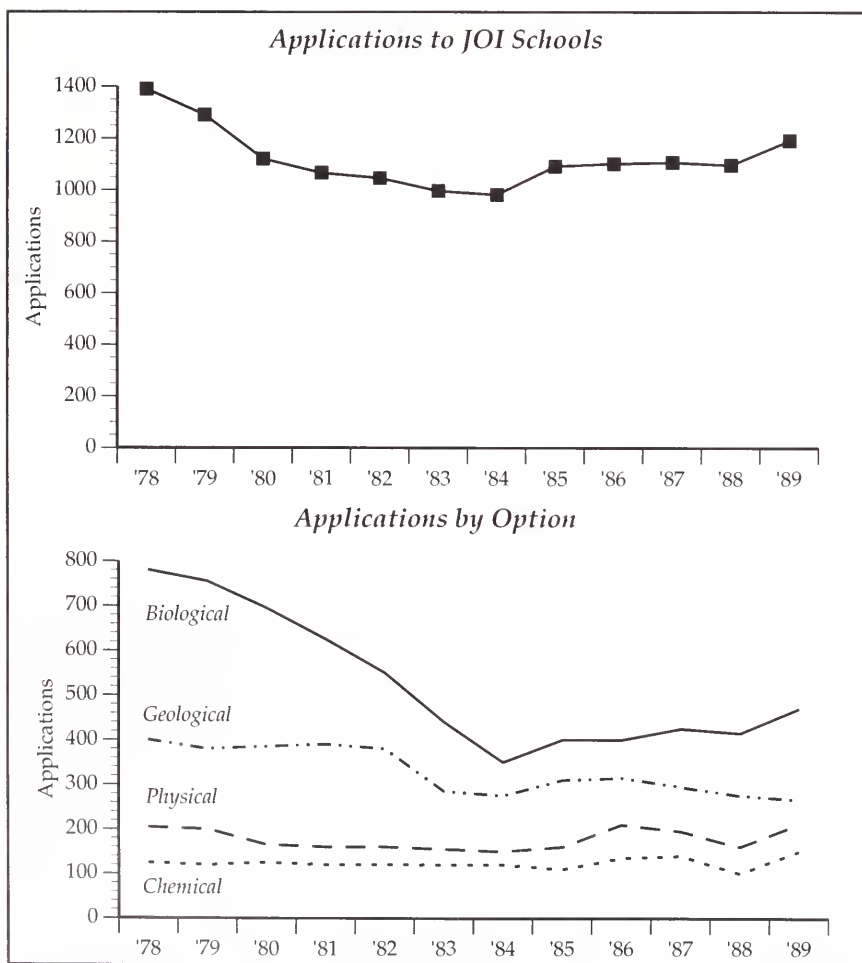
approximately 80 percent of the funded research in oceanography.

Traditionally, the largest subdiscipline of oceanography has been biological oceanography. Marine geology, because of its applicability to offshore mining and oil drilling, has been the next largest. The smallest subfields have been physical oceanography and chemical oceanography. Taken together, applications to these four subdisciplines have started to rebound. In fact, the upward curve of applications has been driven by the overwhelming drop in the number of biological oceanography applications.

The upsurge in environmental interest, reminiscent of the late 1960s, is producing an increase in applications again. Publicity about global warming, sea-level rise, and waste disposal have resulted in increased student awareness of oceanography as a viable career path. But there are important differences today in the upsurge of interest in the ocean compared to those concerns advocated by Cousteau in the 1970s. Today there is a much greater realization that the ocean is coupled to the atmosphere, and that to

understand even the seemingly simplest biological questions, one must understand the physics and chemistry of the ocean.

The upswing in applications during the last six years is gratifying as there has been talk during this period of a declining interest in science overall in the United States. However, there are very few oceanography applications overall when compared to the total pool—on average about 20 from each state! There are approximately 10,000 Bachelor of Science degrees awarded in physics each year in the nation, and yet only 200 applica-



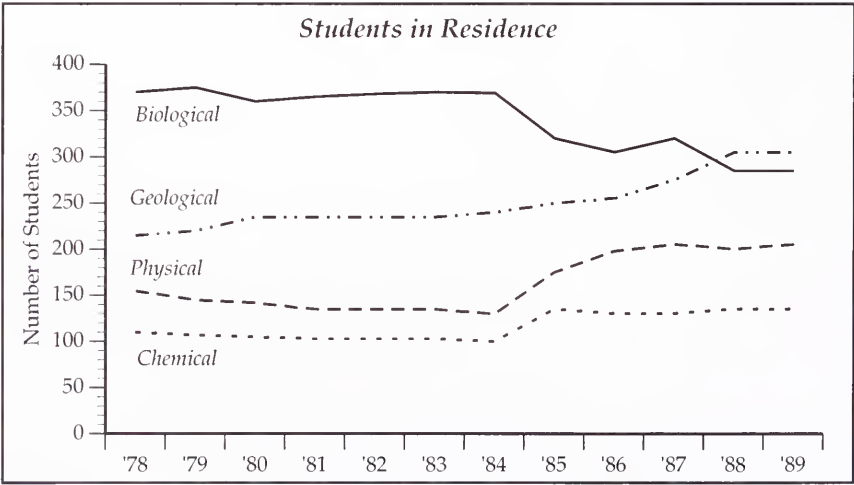
tions are received in physical oceanography. In tracing applications across the oceanographic schools, a total of 1,200 applications come from only 700 persons, with 500 applying to only one school.

These students also are applying to other graduate programs, mainly in the discipline in which they received their undergraduate degrees. Thus, there are only 200 students who apply to a range of graduate programs in oceanography who are committed to getting their graduate degree in the field. Such small numbers lead to an important effect—the good applicants are intensely recruited, often receiving offers from several of the best institutions in addition to others.

While the numbers of applications have changed during the last 10 years from the heyday of Cousteau-based interest, the number of students in residence has remained more or less constant. Each year, approximately 200 students are admitted to the graduate programs at the 10 JOI institutions. So for the last 10 years enrollments have remained constant at approximately 1,000 students-in-residence.

However, during these last 10 years, two notable changes have occurred. Marine geology and geophysics is now larger than biological oceanography, a trend due in large measure to a greater proportion of students in marine geology staying on to complete a Ph.D. In the past they would leave after completing a master's degree to work in the oil industry. The depression in that industry through the latter part of the 1980s left few job opportunities and so many students decided to stay on for a doctoral degree. Second, the decline in numbers of biological oceanography students in residence reflects a decline in the availability of funding for such students.

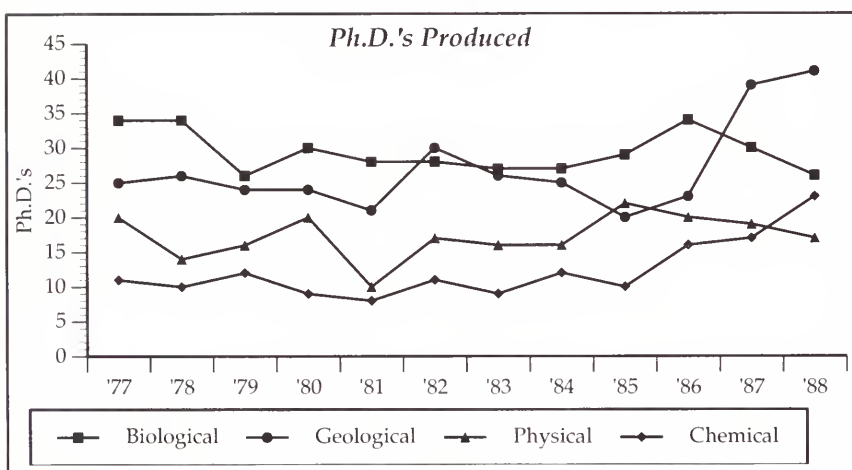
A significant growth in the numbers of physical oceanographers reflects both growing efforts by this segment of the field to attract and retain good students and the availability of funding. Physical oceanography is presently the largest field in terms of research funding, and there are many more job opportunities in this area now than in any other.



While approximately 200 students enter graduate programs each year, about 100 obtain doctoral degrees. This 50 percent "success" rate is normal for a scientific field where there are job opportunities associated with master's degrees. The majority of those students who leave after completing a master's program work for the federal government in agencies such as the National Oceanic and Atmospheric Administration (NOAA), or for the many consulting firms specializing in environmental management.

Doctorates in physical oceanography have the easiest time finding employment. Approximately 18 students a year finish with such degrees and about 50 percent enter education and research at universities, with a further 25 percent entering government laboratories or research agencies. With such small absolute numbers, it is hardly surprising that most students will be well known throughout the community before they graduate. For

the best students, there are offers of postdoctoral appointments. The opportunity to travel, to be based in a coastal city, and to study the environment are most often cited as the reasons why students choose oceanography. Ambitions to feed the world, save the whales, or stave off global warming are



mentioned, but most students select their graduate school as often for family and personal reasons as for reasons of scholarship. Financial constraints rarely enter into the decision as the overwhelming majority of graduate students are supported throughout their graduate career on research or teaching assistantships or on scholarships. Because the stipends from these sources of support are quite similar, rarely do competing economic variables enter into the decision as to which graduate school to attend.

The quality of graduate programs varies among the 10 JOI schools as does areas of greatest expertise. But broadly speaking, to get into one of the schools requires a high grade point average, Graduate Record Exam scores in the 80th percentile or higher, and a strong background in one of the basic sciences. Strong undergraduate preparation in mathematics, chemistry, and physics is required in addition to an overwhelming amount of energy and curiosity.

The decline in interest in science in the United States in the 1980s, coupled with the decline in the number of teenagers, is often linked with the increase in enrollment of foreign students. Some 30 percent of oceanography students today are foreign nationals, an increase from about 20 percent in 1980. While the increase has been driven mainly by applications from China, applications are widely received from throughout the world because many countries do not offer doctorates in oceanography.

But overall, the increase in foreign student enrollment is much less than that observed in other sciences, in large measure because during this same time period there has been a very dramatic increase in the number of applications from women in the United States.

It is tempting to think that most of the women in oceanography are marine biologists, as so often depicted in *Time* or *Newsweek*. However, the last 10 years have seen a steady increase in women entering all areas of oceanography, including physical and chemical oceanography.

This long overdue trend has been achieved because women have been accepted in the field for many years, seagoing cruises are integrated, and an increasing number of women on graduating are entering the professoriate. The reasons for the increased number of women in the field are twofold: because there are now sufficient numbers of women in graduate school, new women entering do not feel isolated or out of place, and, equally important, women now entering the field have superior qualifications to some of those who preceded them. The small size of the field, the camaraderie developed by going on cruises, and the increasing commitment by faculty to enhancing graduate education for women have all combined to provide a very supportive environment.

However, the success rate for women completing doctoral degrees is slightly below that of men, based on a very limited data set. To examine relative success rates, it is necessary to follow each student from entry to completion. Our conclusions are drawn from a study of data from Scripps Institution of Oceanography, the Woods Hole Oceanographic Institution, and the University of Washington.

The average success rates for completing doctoral degrees in oceanography during a 12-year period were 74 percent for male students and 60 percent for female students. This lower success rate is regrettably typical of the sciences in general. All schools are stepping up their efforts to increase the success rates and improve the working environment.

The recruitment of minorities into oceanography also is making progress, though at a slower pace. Today about 3 percent of enrolled graduate students in oceanography are from minority groups. A doctorate in oceanography will not likely lead to a fortune. With about 75 percent of the doctorates in oceanography entering univer-

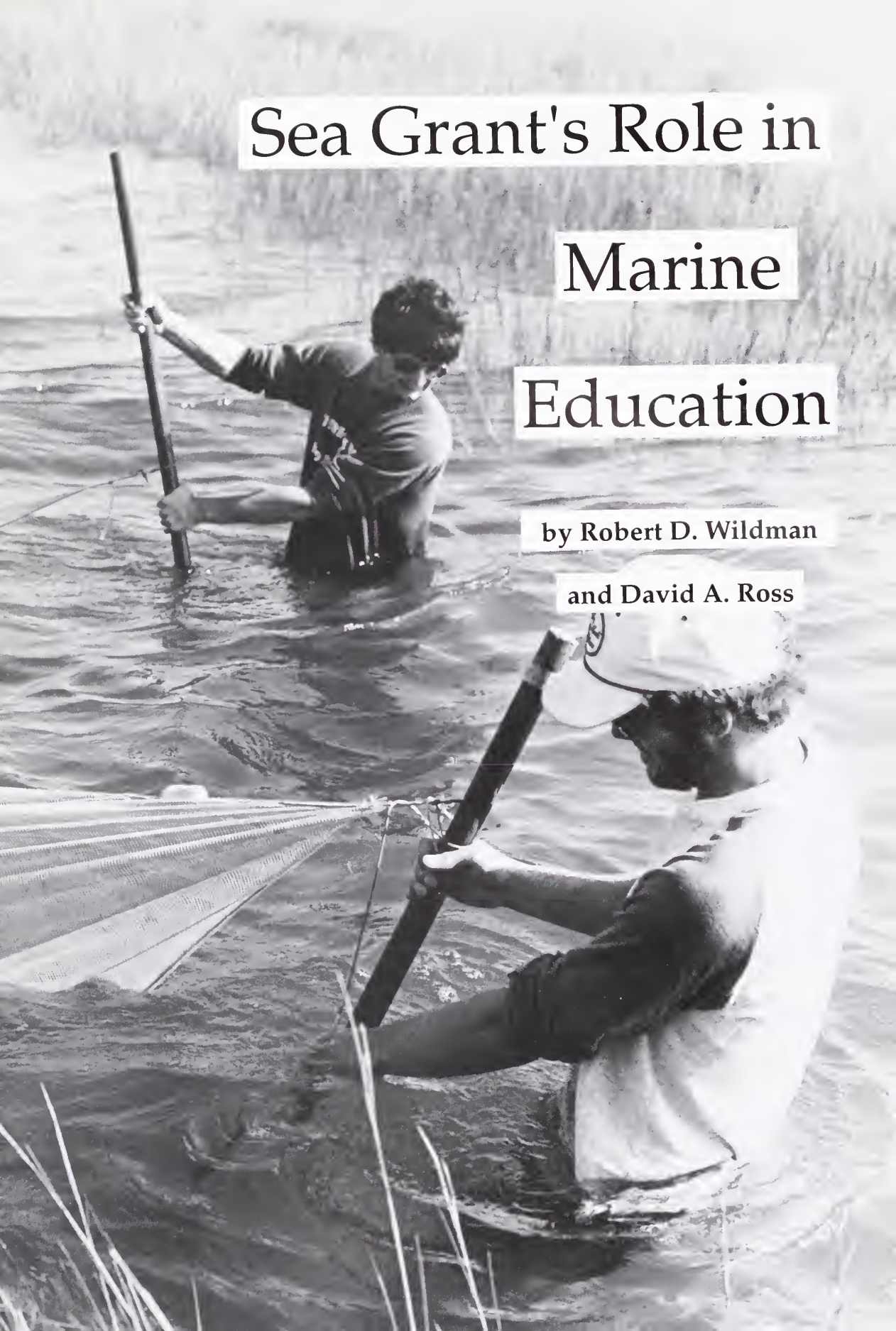
*The last 10
years have seen
a steady
increase in
women
entering all
areas of
oceanography.*

sities or government service, salaries are competitive (a starting assistant professor receives about \$40,000 a year, and rises to about \$70,000 as a full professor. Fame often comes early, for oceanography offers rich opportunity for discoveries of immediate and lasting importance to humanity. But the greatest reward comes from being a member of an elite group of scientists who get to go where few people venture, and to have a chance to think about how two thirds of the planet works. The pleasure of working in a small collegial department, largely focused on graduate education and research, leads to an enviable life. Students and faculty alike have the luxury and the delight of thinking about the blue planet; spending weeks at sea is just one of the unique rewards for those students who seek an adventurous graduate career.

Professor Arthur R. M. Nowell is Director of the School of Oceanography at the University of Washington. Charles D. Hollister is Vice President and Associate Director for External Affairs at the Woods Hole Oceanographic Institution. He formerly was Dean of Graduate Studies at WHOI.

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Sea Grant's Role in Marine Education

by Robert D. Wildman

and David A. Ross

*An NSF study
concludes
that the U.S.
faces a short-
fall of about
500,000
scientists and
engineers by
the end of the
decade.*

Never before have scientific and environmental issues dominated the actions of countries and the concerns of individuals as they do today. Despite the fact that these issues are covered almost daily on the front pages of our newspapers and featured on the evening TV news, a major shortage of scientists and engineers is projected in the United States by the end of this decade. There are only a few programs in the United States that are striving to increase the numbers of marine scientists and engineers. One that is active in the marine area is the National Sea Grant College Program, which is part of the National Oceanic and Atmospheric Administration (NOAA) in the U.S. Department of Commerce.

In a 1989 study, the National Science Foundation (NSF) concluded that the United States faces a shortfall of about 500,000 scientists and engineers by the end of the 20th century and that the number could increase to 675,000 by the year 2006. One simple reason is that college-age students will number only 24 million in the mid-1990s, whereas they were 30 million strong in 1980. On top of this reduction in the available population, only a small portion, about 5 percent, of these students will actually earn a bachelor's degree in science.

A number of reasons have been proposed for the decreased interest and enrollment in science fields. These include the above mentioned decline in the number of U.S. college-age students, which in turn leads to a reduction in the total number of students in all fields. Most of the science community's attention, however, has been directed toward the decreasing proportion of all students now entering science fields versus other careers. Possible causes for this range from the perceived difficulty of science education, to boring course materials, to uninspiring or poorly trained teachers. Of the few students who plan to major in science or engineering when they enter college, more than half fail to receive their degrees in these fields. This is attributed to students finding the course work too difficult, finding other fields more interesting, or believing the job prospects to be better in other fields.

One way to improve this situation is to attract larger numbers of women and minorities to science and engineering. Women at present earn about a third of the doctorates awarded in science, but most tend to be in the social sciences and psychology. For Blacks and Hispanics, the situation is even less favorable. While Blacks constitute 12 percent of the population, they only hold about 2 percent of the scientific and engineering positions. Hispanics constitute close to 9 percent of the population and they, too, only hold about 2 percent of the science and engineering positions.

In 1989, nearly 9,600 Americans received Ph.D.'s in the natural sciences and engineering. Only 133 of these were awarded to Blacks (of a total 811 in all fields), and this was the highest number yet

achieved. Of these 133, only three were in the Earth, marine, and atmospheric fields, or less than 0.5 percent of those awarded in 1989. Asians received 427 Ph.D.'s in science and engineering (out of a total of 624); for Hispanics, the numbers were 186 of 569, and for American Indians, 37 of 93.

On the other hand, a third of the earned Ph.D.'s went to foreigners studying in the United States. These small numbers of minorities in the sciences are a national shame; there are scientific opportunities for women and minorities in science, particularly in marine sciences, that should be tapped. Indeed, if the predicted shortfall is to be avoided, large numbers of women and minorities must be attracted to scientific or technical careers.

In the United States, the training of marine scientists at the Ph.D. or master's level has frequently been a controversial matter. One school of thought prefers that students be fully trained in the fundamentals of a basic science (for example, biology), and in their thesis research—and later in their careers apply this basic knowledge to the marine environment. The other position holds that students should be exposed in their training to all fields of marine science, but specialize in one specific subdiscipline – for example biological oceanography. Surprisingly, feelings often run strong concerning which of these two procedures should be used. At the risk of a pun, the argument may just be academic for the 21st century.

There are three major problems that the marine scientific community must solve in training the necessary talent needed for the coming century. These are 1) the general lack of national interest in science as a career among college-age and younger students; 2) the changing skills needed by oceanographers



In a subsea setting, students (above) map and survey marine archaeology during a University of Hawaii Sea Grant workshop at Oahu. They home in (below) on the remains of a light beacon.

in the 21st century; and 3) the impact of “big” science and advancing technology on the individual researcher and graduate student. These hurdles can be overcome, but it will take a national effort.

Marine science is undergoing some major changes. This includes the realization that the oceans play a critical role in the worldwide process of global change. To answer some of the questions related to global change, several new, large-scale research programs have been developed. These will be decade-long in duration and involve innovative ways of collecting data, such as by satellites. The oceanographer who will work in these programs will be different from the sea-going scientist of years past, as familiarity with computers may become more important than sea-going skills.

Real possibilities exist for making inroads on the three problems cited above through marine education and training programs. The National Sea Grant College Program sponsors work in marine research, marine education, and marine advisory services (see *Oceanus*, Vol. 31, No. 3). Through its network of participating academic institutions, Sea Grant has been actively involved in increasing the supply of well-trained, and educated specialists in marine science and marine affairs, and in making the public better informed about the wise use and protection of the marine environment and its resources.

Sea Grant’s marine educational activities can be categorized as follows:

Course Development and Student Projects: Includes efforts to improve undergraduate and graduate level instructional programs in marine sciences and related fields. The projects help universities introduce new knowledge and methodologies into their instructional programs. Federal support is offered for a short period of time and only for development efforts that clearly exceed normal university resources available for this program.

Research Assistantships: The estimated numbers of graduate research assistants (GRA’s) who have received at least partial support from Sea Grant in recent years are shown on page 43. Note that the table includes all the GRA’s supported by Sea Grant, not just those in separate education projects.

Elementary and Secondary Education and Teacher Training: Investigators supported by these projects develop educational materials to be used in elementary and secondary classrooms, evaluate and disseminate the materials, and instruct teachers in their use. They also provide back-up support to teachers and administrators who are trying to introduce marine and aquatic education into their school systems.

Non-Formal Education: Includes marine and aquatic educational activities that occur outside formal classroom structures. The potential audience is the entire American public in all its diversity. Activities typically include lectures, conferences, 4-H and Scout projects, beach walks, and radio and television shows. These

***Numbers of Graduate Research Assistants (GRA's)
Supported by Sea Grant in Past Decade***

<u>Fiscal Year</u>	<u>GRA's</u>
80	560
81	501
82	523
83	500
84	538
85	520
86	504
87	497
88	429
89	430

The numbers refer only to graduate research assistants, while graduate students who work in education, marine advisory service, and program administration are omitted.

activities often take place at science centers, museums, and aquaria.

Technical and Vocational Education: Includes projects to begin technical training, vocational training, and pre-baccalaureate technical training programs that typically are offered at junior or community colleges and technical institutes.

Sea Grant Fellowship Program: Includes projects intended to help stimulate interest in marine careers among those whose background or previous training might not have generated such interest.

Sea Grant Fellows (John A. Knauss Marine Policy Fellowship): This program supports highly qualified and motivated graduate students while they work on marine policy issues for one year in the legislative or executive branch of the federal government. The program is intended to round out a student's academic training and give him or her some experience at the federal policy-making level. The program has been in existence since 1979 and has supported 152 students to date. Public Law 100-200 renamed it the Dean John A. Knauss Marine Policy Fellowship Program after the former Dean of the Graduate School of Oceanography at the University of Rhode Island and current NOAA Administrator.

The total amount spent in these categories was \$4,941,000 in Fiscal Year 89, of which \$3,023,000 comes directly from NOAA Sea Grant, and \$1,918,000 was matched or in-kind support from participating institutions.

Sea Grant-supported college graduates include not only some in the classical fields of oceanography, but also many trained as marine specialists in law, economics and social sciences, medicine and pharmacology, engineering, and transportation and energy.

*Some 10,000
students
to date
have been
supported
by Sea Grant
in various
marine fields*

The number of students supported by Sea Grant to date is approaching 10,000. Concurrently, hundreds of thousands of adults are reached through Sea Grant's Marine Advisory Service and Communications Programs with information on ocean and Great Lakes resource concerns.

National Marine Educators Association: In the 1960s and '70s, Sea Grant was one of the few organizations supporting marine education. Some of this support helped start the National Marine Educators Association (NMEA). NMEA was officially formed in 1976, although an "unofficial" group of individuals interested in marine education had been meeting since the mid-1960s. NMEA is now an independent organization with 15 regional chapters and more than 1,500 members. It holds annual and regional meetings and publishes a magazine: *Current —The Journal of Marine Education*.

Among the purposes of NMEA, many of which parallel Sea Grant's interests and help in developing marine scientists, are:

- To provide a medium for the exchange of information and teaching materials;
- To stress the interrelationships of marine education to all disciplines and other educational experiences;
- To make available to educators information concerning the selection, organization, and presentation of marine materials at all levels; and
- To work for the improvement of the professional qualifications of marine educators.

What then can marine science in general, and the Sea Grant Program in particular, do to contribute to solving the dilemma of reduced graduates in the sciences? Clearly, they cannot and should not attempt to reshape the entire U.S. science education field, an approach more appropriate for the National Science Foundation. Rather, Sea Grant should use its limited resources in complementary approaches that can make contributions for which the marine sciences have unique capabilities.

The oceans and the organisms that inhabit them still have a romantic allure for most people. Professionals involved in marine education in any capacity can take advantage of that fact to interest young people in science careers and the marine sciences in particular. During their educational development, students can be made aware of the wide variety of career fields open to them, many of which do not require a Ph.D. While a solid foundation in mathematics and natural sciences is a requirement for several career paths, it can be attained in a way that is much more appealing and less threatening to students.

In the realm of elementary and secondary educational programs, Sea Grant can enhance its efforts to make available stimulating instructional materials that can be infused into K-12 curricula in nonscience as well as science courses. This approach could lead to

more student awareness of and interest in science as a field and in marine science affairs specifically.

Communicating the many problems and opportunities involved in human interaction with the marine environment should be simplified and expanded to reach a wider public audience. Casting a larger net on marine issues to the public could increase interest in the pursuit of marine science careers.

Then enters the national priority of teaching the teachers. Improving curricula and enhancing out-of-classroom experiences for science teachers at the K-12 and post-secondary levels should translate back into increased career interest by the student population. At the graduate school level, assistantships and pre- and post-doctoral fellowships should be targeted toward specific job categories to fill identified needs, and toward minorities and women to take advantage of these increasingly important sources of marine careerists.

As with most problems facing us today, the balancing of supply and demand for marine science and marine affair specialists is not likely to yield to singular, simplistic solutions. Only carefully considered, multiple approaches are likely to lead to the desired results during this and the next decade.

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The authors would like to thank Judith Fenwick and Victor Omelczenko for their reviews and comments on this article. Much of the information related to the problem and shortage of scientists in the future was reported by R. Atkinson in the April 27, 1990, issue of *Science* magazine (Vol. 248, p 425-432).

Teaching teachers is a national priority as is expanding public awareness of the opportunities and problems in the marine arena.



The Ocean as a Classroom

*The Role of Practical
Experience in
Science Education*

by Susan E. Humphris

There have been numerous reports recently calling for a nationwide reform in science education. The American Association for the Advancement of Science has sponsored two such reports, *Science for All Americans: Project 2061*, and *The Liberal Art of Science: Agenda for Action*. These reports highlight two major concerns of science educators.

The first concern is the need to develop a citizenry with a level of scientific understanding sufficient to make informed policy decisions concerning scientific and technological advances. The second concern is the need to ensure a continued

The SSV Vestal, a 125-foot schooner, is fully equipped for deep-sea oceanographic research, providing students with practical experience in multidisciplinary programs about the ocean.

supply of highly motivated students entering scientific careers.

These reports have emphasized familiarity with the natural world as a basic dimension of science literacy. They also have recommended that major curricular changes be made to include natural sciences as part of a liberal arts education.

In the last few years, there also has been increasing recognition of the impact of human activities and advances in technology on our planet. Although much concern has been generated by highly publicized catastrophes, both real and threatened, such as oil spills, plastic pollution, and global warming, there is growing interest and fear about the long-term habitability and survival of the Earth.

The oceans are an excellent place for understanding these concerns and their long-term implications, and they are an excellent place to teach science.

As a natural system, the oceans present physical, chemical, geological, and biological principles in a dynamic environment that everyone can readily appreciate. Their high level of complexity and degree of unpredictability allow students at any level to carry out experiments and answer their own questions.

The oceans involve students in multi-disciplinary problems that cut across traditional subject boundaries. Furthermore, the oceans' fluid nature and worldwide circulation mean that local activities affecting the marine environment can have a global impact. The oceans integrate environmental awareness and science education.

Use of the marine environment to teach science so far has been relatively unexploited. There is a tendency to view marine science as the domain of scientists conducting research in private and government institutions, colleges, and universities.

In fact, students seriously interested in pursuing graduate studies in the field are advised to first obtain a firm grounding in the basic sciences while undergraduates so they may apply this to the ocean system at a later stage. But without some early, engaging exposure to learning about the ocean, how do young people



*Rebecca Buchthal
(above) aboard the SSV
Westward presents her
research on Florida's
spiny lobsters.*

*Sea Semester students
(below) deploy a
Neuston net from SSV
Westward.*



become motivated to pursue careers as marine scientists?

In a recent informal survey of a group of practicing oceanographers conducted by Dr. Leslie K. Rosenfeld (a physical oceanographer at the University of Miami's Rosenstiel School of Marine and Atmospheric Sciences), the most important experience that determined their career choice was participation in research which, for many, occurred during summer field courses. Incorporation of the ocean system into science curricula at all educational levels can only serve to increase awareness about marine research and the possibilities for careers in the marine field. This is critical if there is to be a continuing supply of students entering careers in marine science.

For the typical liberal arts student, who is going to pursue a non-scientific career and yet will be faced with public policy decisions that are based on scientific arguments, basic science courses can seem abstract and irrelevant to their daily experiences and something to be avoided. However, most students today are concerned about preservation of the environment. Converting this interest into creative inquiry, bolstered by explanation of observations, is a powerful way to involve students in science.

For younger students, simple observations about our oceans can be used to introduce basic physical, chemical, and biological principles in the context of the natural world, as opposed to teaching exclusively from abstract examples out of textbooks or from experiments that have little to do with the students' life experiences.

At higher levels, students apply this knowledge of basic scientific principles to investigate further the characteristics of the ocean system. In essence, structuring the learning of science around observations of the students' own world brings relevancy to what is viewed by many as an esoteric and abstract subject. The excitement of "discovery" is an important part of scientific inquiry that can be realized when students make their own observations of the world around them.

Clearly any educational reforms that emphasize the application of scientific inquiry into the natural world must involve students in some practical experiences. During the last 19 years, the Sea Education Association (SEA) in Woods Hole, Massachusetts, has been experimenting with this idea, initially with undergraduates selected from universities all over the country. More recently, SEA's programs have involved school teachers in an effort to help them make science learning at other educational levels more relevant and exciting.

The theme of SEA's programs is the marine environment as seen through application of scientific research at sea. In the undergraduate program, basic scientific principles are used to explain how our oceans work. In the teachers' programs, the oceans are used as a theme to introduce basic scientific principles into the classroom.

A brief description of the structure of SEA's undergraduate

*Simple
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program known as “Sea Semester” is necessary in order to put further comments into context. Each Sea Semester is designed to be part of an undergraduate liberal arts education. Presently, 50 percent of those students attending SEA are science majors, 45 percent are non-science majors, and 5 percent have not yet declared their major.

The semester-long program is dedicated to learning about many aspects of the ocean world through six weeks of course work ashore in Oceanography, Nautical Science, and Maritime Studies. This is followed by six weeks aboard a research sailing vessel, during which the students participate in research as well as vessel operations.

One of the most important outcomes of developing a program around a natural system is its approach, which by necessity is multi-disciplinary and integrated. In general, conventional science programs do not explore the interrelations among the sciences in a situation that is meaningful to the students, much less the interrelations between the sciences and non-sciences.

Students are commonly unaware that the physical principles determining weather patterns and wind directions also can be applied to ocean circulation. Or that oceanographic characteristics often play a vital role in fisheries disputes. Or that in steering a vessel by magnetic compass while accounting for variation, they are using the same physical phenomena that geologists use to date the ocean floor. In addition, incorporating maritime literature written from the forecandle and the quarterdeck enhances the students’ own experiences of going to sea.

Practical experience also gives students an opportunity to conduct research and discover the way science progresses. Typically, science courses become means of transmitting factual information through lectures, textbooks, and laboratory activities. Students are presented with “the scientific method” as dogma, and follow it carefully in lab exercises. Once given a chance to conduct scientific research, students quickly realize there are many approaches to appreciating that research requires creativity, both in the design of a project and in the interpretation of data. And that “doing science” only means adopting a creative, rigorous, and logical approach to finding the answer to a question.

The limitations of conventional methods of teaching science become evident as SEA students go through the process of designing and completing their research projects. For many of them, especially those with perhaps only one college-level science course, this is the first time they have been expected to complete a scientific research project, and they are filled with apprehension about their ability to handle independent research.

The science courses they have taken have not given them an appreciation of how to go about scientific inquiry. Though they

Conventional science programs do not explore the interrelations among the sciences in a way that is meaningful to students.

Trying to collect data on the high seas quickly dispels the glamour of working in the ocean as typically portrayed by the media.

have been involved in “hands-on” science projects, they find themselves ill-prepared for in-depth research. This suggests that “hands-on” learning can be as ineffective as any other teaching technique unless the students’ interest is aroused, their minds involved, and they have some responsibility for the results. This latter stipulation, responsibility for the results of their actions, whether it be deciding where to take a sample or changing the ship’s course to reach the next science station, is critical to successful education in a practical, “hands-on” situation.

There is an interesting consequence of science being presented in the conventional way through textbooks, which typically present ideas, facts, and laboratory exercises that always work and usually reconfirm or demonstrate an already known fact. That consequence occurs when students go in the field and collect data for a project, and discover that they are not prepared for the possibility that their data may not fit their hypotheses. The common responses from astonished students are that their project “has not worked” or their data “are wrong!” The idea that perhaps their original hypothesis was incorrect does not occur to them. They are simply used to lab activities that work and prove a point.

Another important aspect of practical experience in science education is the exposure of students to the realities of working within the system they are studying. Natural systems are complex, unpredictable, and continuously changing. Trying to collect data in a torrential rainfall or in high seas quickly dispels the glamor of working in the ocean as typically highlighted by the media. The difficulties that marine scientists face in conducting research also are conveyed by this experience, and this increases students’ awareness that limitations are imposed on the scientists’ ability to further knowledge.

The type of program described here involving intensive study of the ocean system is best suited to the undergraduate level. Presently, there are a number of marine field stations that offer programs to college students, thereby providing valuable opportunities for practical experience for both the science and non-science major.

Of 34 organizations surveyed in 1989, there were 131 different courses offered of a week or longer in duration by 23 organizations (25 responded to the survey). Of these, the majority were courses in a specialized topic, with only 9 percent providing general marine science or oceanographic experience. If the goal is to produce a citizenry informed about the oceans, the number of multi-disciplinary courses needs to be increased.

But studies of the ocean can begin long before the college level as a way to introduce students to basic scientific principles. Although it is unrealistic to expect every student to learn all they can about science through direct observation of the natural world, classroom and field activities can be developed that allow students

to “discover” scientific ideas.

If the concept of marine science as one of the themes for science education is to be enhanced, teachers must become acquainted with the subject material, become excited about the marine environment, and develop classroom and field activities that illustrate underlying

scientific principles. Examples of such activities include introducing waves and their general characteristics by direct observations or in a simple wave tank, studying buoyancy and Archimedes' principle through loading and unloading model boats, teaching vectors using navigation problems, and illustrating density by modelling deep ocean circulation.

These ideas will take time to develop, but the outcome could provide the next generation with an appreciation of the relevance of science to themselves and to the future of their environment.



Students work in the shipboard lab completing analyses on their individual research projects.

Susan Humphris is Dean of the Sea Education Association and an Adjunct Scientist at the Woods Hole Oceanographic Institution.

Results of the 1990 Readership Survey

To the 2,500+ persons who responded to the Readership Survey distributed last Spring, we thank you for answering the questions, and for offering your valuable comments. We received numerous requests to publish the results, so we note some of the highlights here.

Quality of Oceanus:

- More than 95 percent of the respondents found the magazine to be accessible, with understandable and informative illustrations, and good or excellent editorial quality. Ninety percent felt that the design of the publication was attractive. Ninety-two percent refer to back copies of *Oceanus* occasionally or frequently, and most retain their copies for four or more years.

Demographics:

- Seventy-seven percent Male and 23 percent Female; average age is 49 years.

Employment:

- Thirty-four percent of the respondents are employed in an academic field, 27 percent in a field of applied marine science, and 13 percent in the military.

Educational Background:

- Fifty-six percent hold graduate degrees of which more than 23 percent are doctorates.

Muses in the Rigging

Music, Education, and the Sea

by Tom Goux

Just what might Terpsichore and Calliope have to say to Clio and Urania about Poseidon's mysterious domain? On occasion I have seen the muses of singing and poetry consult with the muses of history and science—regarding how mortals come to learn about the sea.

*Tell me, Muse, about the man of many turns, who many
Ways wandered when he had sacked Troy's holy citadel;
He saw the cities of many men, and he knew their thought;
On the ocean he suffered many pains within his heart,
Striving for his life . . .*

—Homer, opening lines of *Odyssey*

The sea and music: big subjects. For tellers-of-tales, for poets and bards through the ages, *the sea is music*. From Homer to Hemingway, there is the echo of the howling sea-storm, the pulse of the rolling swell. In this electronic century, composers like Claude Debussy, Benjamin Britten, and Percy Grainger have set great symphonic tides in motion as the sound of their music has washed over the entire globe. For them, for me, for many, *music is a sea*: a wondrous, deep expanse filled with wonder and surprise.

Music holds and sometimes hides secrets of an astonishing past and offers for our discovery, myriad possibilities, pleasures, and puzzlements. And this, of course, is how the teachers and students of things maritime and marine view the ocean.

*"Wouldst thou,"—so the helmsman answered,
"Learn the secret of the sea?
Only those who brave its dangers
Comprehend its mystery!"*

—Longfellow, *The Secret of the Sea*



*The rousing
sea chantey
changes the
view from the
dunes, puts
packet ships
on the
horizon, even
animates the
figureheads in
the maritime
museums.*

For some 15 years I have collected the songs and poetry of the sea (traditional and contemporary music and verse of seafaring folk in North America, the British Isles, and other places). This endeavor has been a special part of my teaching and learning life. I have presented this material to a great variety of listeners in concert, museums, school lectures, demonstration situations, and teacher educational workshop settings.

During these years, while singing and playing throughout the New England region and residing in a community of prominent oceanographers and marine biologists, I have watched all manner of “students” learn about maritime and marine subjects.

*From Boston Harbor we set sail,
And the wind wuz blowin’ a devil-of-a-gale!
With the ring-tail set all abaft the mizzen peak,
And the dolphin striker ploughin’ up the deep.*

—*Boston Harbor, a traditional chantey*

At one end of that student spectrum, there is the guy who’s been dragged (by well-meaning friends or relations) to a concert or museum event, or a group of senior citizens who pulled up at the National Seashore Visitors’ Center on Cape Cod—folks who happened on a scene, who stumbled across a story being told, but were not ready to listen. For these “learners,” music can turn the educational tide. The 19th century sailor’s ballad, or the rousing sea chantey, changes the view from the dunes, puts packet ships and fisherfolk on the horizon, even animates the figureheads and ships models in the maritime museum salon.

*Oh, the pilot comes up and these words he does say,
“Get ready, my boys, your ship’s goin’ away”
We braced all her yards and we gave her the slip,
And down Boston Harbor that packet did rip!
And now we are sailin’ down off of Cape Cod,
Where many a hard flashy packet has trod,
The wind it breezed up and the sea they did boil,
And at eight bells that night we clewed up our main royal!*

—*The Dom Pedro, a traditional fo’c’sle song*

At the other end of the student spectrum is the very focused, intense setting, such as a gathering at the Sea Education Association (SEA) in Woods Hole, Massachusetts, which involves participants in what might be called a totally sea-related educational experience. Its six-week curriculum ashore extends into and is uniquely amplified by another six-week period of ocean-going study aboard a large sailing vessel (see article page 46).

It was in this setting that I was first asked to “sing a few sea chanteys” and speak, as a contributor to the humanities component



of the course, about the ancient and on-going traditions of *music at sea*. At the outset then, this music was part of a history syllabus, but music, once it is being sounded, is not history: it joins us in the moment. For me (and many SEA students) music-and-the-sea became much more than a happy evening of sea chanteys.

In the middle ground, between the intensity of the SEA experience and the happenstance of the random visitor at the maritime site, there are all sorts of school, institute, festival and workshop settings—places where learner and teacher have deliberately come together with varying degrees of interest and involvement.

The teaching function of the maritime museum, the museum of natural history, and the modern aquarium has vastly expanded in recent years. It is in places like museums that many people are first exposed to the disciplines of marine science and maritime history.

Museums are great places to watch (and maybe help) people learn about the sea. On any given day, visitation to a place such as the Kendall Whaling Museum of Sharon, Massachusetts, Mystic Seaport of Mystic, Connecticut, or the Peabody Museum of Salem, Massachusetts, can bring a broad spectrum of interest (or disinterest) through the door. The artifacts are astounding and the information and insight offered through careful curatorial and interpretive efforts are truly remarkable. However, old stuff from the past lying silently in glass cases can possess a certain morbidity. Need these accomplishments of men be mute in their afterlife? Cannot these reflections of ambition and endeavor be preserved along with echoes of their times? Of course they can. In any room full of artifacts, there most likely exists retrievable melodies and verses to fill that room with musical sound and sentiment.

*In any
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that room.*

When white sailors came into contact with black seamen, a new chemistry resulted and vigorous worksongs developed known as chanteys.

As with the historical objects themselves, careful collection, preparation, and presentation is crucial. The maritime institutions mentioned previously, and others (the *USS Constitution* Museum at the Charlestown Navy Yard in Massachusetts, the maritime wing of the Smithsonian's Museum of American History in Washington) have musical and other aural elements in their programs that not only breathe life into their collections, but into their clientele as well! The music I use in these situations begins with sailors' songs of the last century—chanteys, ballads, and ditties of the age of sail—but by no means ends there.

The chantey, in and of itself, is an interesting musical and historical occurrence. In purely historical terms, the chantey, the blood-and-bone work-song, a specialty of the Yankee and British seafarer, is rich and wonderful. As Dr. Stuart M. Frank, Director of the Kendall Whaling Museum, has written:

In the Age of Cotton, early in the 19th century, when that great Southern cash crop was a mainstay of the young republic, Yankee and British ships carried raw cotton from Southern ports to the factory towns of the North and to England and beyond. Most of the laborers who loaded the bales were black, many of them slaves hired out by their masters for this arduous work of *steaving* or *screwing* cotton. Like their ancestors in West Africa and their kinfolk harvesting cotton on plantations in the American South, these *stevedores* tended to sing at their work: solo-and-response songs with a lead singer, and the crew joining in on the choruses. The style is familiar in so-called Negro spirituals and chain-gang work-songs.

Sailors had been long accustomed to singing on shipboard, and Navy crews commonly worked to the rhythms of fiddles, fifes, and drums. But when the white sailors came into contact with these Afro-American longshoremen—and, eventually, when some of the black dockworkers went to sea as sailors—a new chemistry resulted, and a vigorous, hybrid repertoire of shipboard work-songs developed that came to be known as *chanteys* (pronounced, and sometimes spelled, *shanties*)."

*When I was a young man and in my prime, Way down in Florida!
I chased them yaller gals two at a time! An' we'll roll the
woodpile down!*

*Rollin'! rollin'! rollin' the whole worl' round,
That brown gal o' mine's down the Georgia Line,
An' we'll roll the woodpile down!*

—Roll the Woodpile Down, a traditional chantey

But work songs were certainly not the only songs of the watery world of Sailor Jack. In many ways, shipboard life was a society unto itself, and the musical entertainment of that society came from within. Dr. Frank continues:

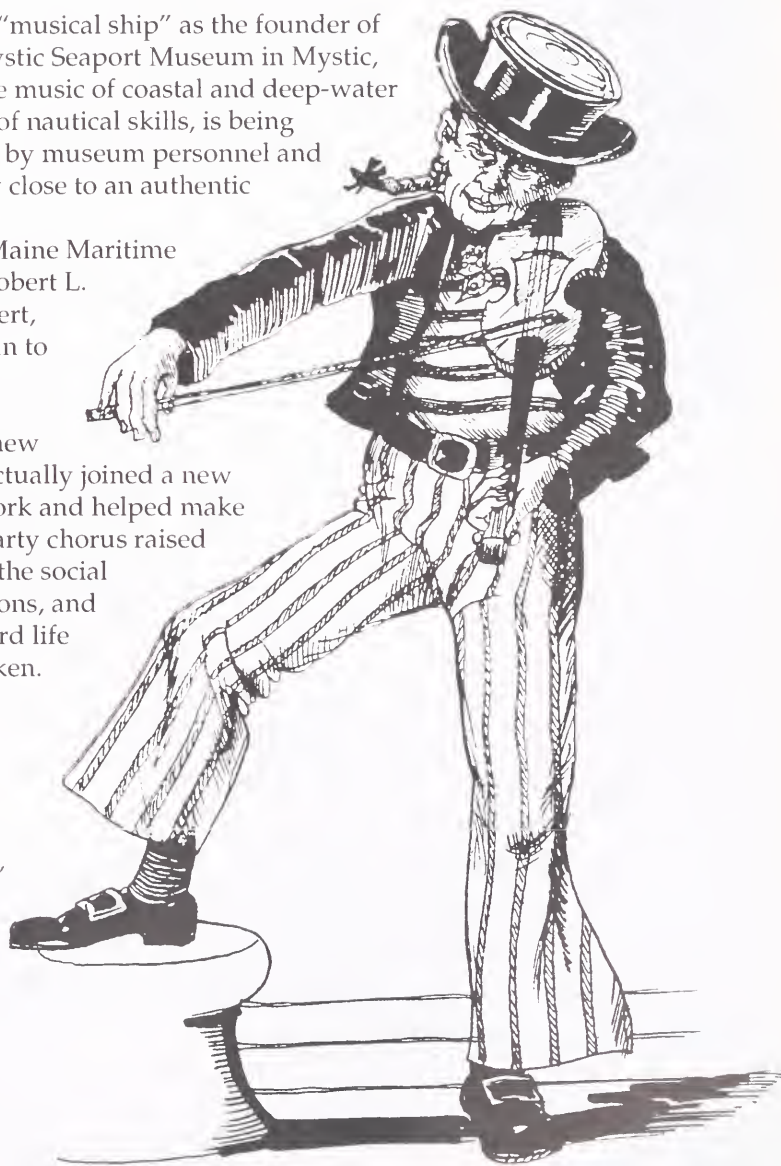
Like people everywhere, sailors wanted to fill their precious leisure hours with music. Songs of any kind might do, and sailors are known to have sung whatever was popular ashore, as well as old ballads, “sea songs” on nautical themes and sundry ditties of sailor manufacture. Like many *chanteys* (work songs), many of these *fo’c’sle songs* (so called after the *forecastle*, where typically the crew lived aboard ship and passed much of their off-hours time) gave voice to the triumphs and deprivations of sailor life, in yarns about events at sea, women ashore and the hapless plight of Jack Tar. . . . And while chanteys were the exclusive province of the common seamen (who sang them at their work), after-hours music was everyone’s domain.

Officers and shipmasters—as well as captains’ wives and families on so called “hen ships”—were as likely as anyone to enjoy music and to participate in occasional musical entertainments held on many vessels for the pleasure of all. Richard Henry Dana, and many seafaring men and women in their letters and diaries, have remarked that a “musical ship” was likely to be happier than any other.

Dr. Frank himself fitted-out a “musical ship” as the founder of the sea chantey program at the Mystic Seaport Museum in Mystic, Connecticut. At Mystic Seaport the music of coastal and deep-water sailors, along with a great variety of nautical skills, is being revived, practiced, and *experienced* by museum personnel and visitors; offered in something very close to an authentic setting.

Similar things happen at the Maine Maritime Museum in Bath, where curator Robert L. Webb, another nautical music expert, reminds us that sailors of old began to sing just as soon as they joined a ship’s company. Surrounded by strangers, taking directions from new bosses, learning new tasks, they actually joined a new society. The chantey paced the work and helped make the boat go, but a good song, a hearty chorus raised by all hands, helped give heart to the social order of the fo’c’sle, relieved tensions, and helped define the rules of shipboard life perhaps unwritten or even unspoken.

*The Ebenezer was so old, sir,
She knew Columbus as a boy, sir,
Pump her, bullies, night and day,
To help us get to Liverpool Bay.
Wet hash it was our only grub, sir,
For breakfast, dinner and for
supper,
The bread was as hard as any
brass*



And the meat was as salt as Lot's wife's ass!

—*The Ebenezer*—a traditional chantey

When, in our day and age, students of the sea go to sea, there are occasions when these same, apparently timeless, things happen. Here are the comments of Captain Carl Chase, an expert in two fields: he holds a degree in music from Harvard University and certification as a ship's master. For many years, he was one of the teaching captains for SEA aboard the SSV *Westward*:

*Going to sea
can be one of
the few
situations
where people
must provide
music for
themselves.*

In reflecting on what I have observed of music-making at sea, I realize that in these days "going to sea" can be one of the few situations where people are thrown back on their own resources to provide themselves with music. Of course this need not be so—you can bring along a Walkman and tape collection—but, in the SEA program and other circumstances under which I have spent most of my time at sea, this was not permitted! At SEA, Walkmans were banned to discourage people from withdrawing from the group and "zoning out" under headphones. Furthermore, on my trips anyway, I rarely if ever allowed the playing of recorded or radio music on the ship. My stated reason for this was consideration for each other in a crowded setting. My unstated reason was to create a musical void, which I knew people would soon fill by making their own music—which would then become a meaningful part of the fabric of shipboard life and daily routine.

Being captain, I was in a position to aid and abet this process, but it would have and did happen on other trips as well, where the leaders were not "musical types."

What actually happened was no different from what has gone on since the beginning. People would eventually overcome initial shyness and begin to sing and/or play instruments. They would sing to pass the time (at the wheel, on lookout duty), they would sing to make the work go easier (in the galley, scrubbing the ship), they would sing to vent feelings, and they would sing and play to entertain each other.

At first the material would be familiar: current songs from what they knew and liked ashore. These would be the songs that everybody knew. Singing them served—as ever—to bring the group closer together. Eventually, often surprisingly quickly, one or more of these would emerge as group favorites and begin to be personalized—words added or changed, whole verses made up, or a special arrangement worked out with particular instrumentation or interpretation. Now it became their song.

On many occasions, the ultimate (in my opinion) happened and someone—or a collaboration—would present an entirely original song. Nine times out of ten this would be a true shanty or calypso in that it would hide some more or less serious social commentary under the façade and guise of innocent music and lyrics. Thus, in the 1980s, just as for centuries past, we had crew members roasting their superiors,

lamenting the lack of sex and alcohol, and expressing deep sadness at the prospect of leaving good friends—potentially heavy emotional issues harmlessly vented through music!

*Well, I really can't complain, this cruise sure has
been swell;
I've learned to do without the things I love so well.
Still when we hit port, I don't know which I'll do
first, I guess it all depends on which thirst is worse
For beer, sex, beer, sex, beer, sex, beer, sex, beer.....
Chorus: Take your pick!*

—*The Westward Blues*, by David O. Brown, W-72

The need for music must be basic to the species. Nowadays we are usually oversaturated, but it doesn't take long for the need to reassert itself when we are confronted with an environment which hasn't any. . .

—*excerpt: Sail on the Westward*

It's obvious Captain Chase values, as did other master mariners before him, the presence of music on board. Not simply because it makes for a jolly ship, but because it can help open the mind in a way that instructions may not, in a way that (dare I say it?) instructors might not. The point is, that SSV *Westward* is a teaching environment: Carl Chase knows that the reception of information, of concepts, of *what the learning situation has to offer* is facilitated, energized, and enhanced by the attendance of the Muses!

*We set sail on the blue-green ocean
'Til the land was out of sight,
'We watched dolphins as they gaily
romped
And splashed in the morning light.
We felt the salty sea spray
As we travelled from day to day,
Beneath the stars we quietly sailed
On the path of the Milky Way.*

Chorus.

*We've had many things to laugh about
We've had times both high and low,
We started out as strangers here
Now together we all will go.
When I'm down and out, when I'm weary,
And I'm tired at the end of the day,
I'll think of those starry evenings
On the path of the Milky Way.*

Chorus.

—*Sail on the Westward*, by Chrissy King, W-57

**Crew
members
roasted their
superiors,
lamented the
lack of sex
and alcohol,
and expressed
deep sadness
at the
prospect of
leaving good
friends.**

Marine studies and maritime history programs use music to "sweeten" the curricular content, especially for the beginning student.

What can be seen in these various settings where people, by conscious act or otherwise, present themselves as learners about the sea, is a dynamic sorely affected by the element of artful sound and language. It's curious to me that the predisposition of the student is often somehow unrelated to this effect. Both the individual who happens to stumble into the maritime exhibit and the serious student, who may have traveled hundreds of miles and spent thousands of dollars for his or her oceanic edification, are equally surprised, somewhat changed by the addition of a carefully prepared aural component. Care and preparation are as crucial here as in any educational formula, for we are talking about much more than *just a sound track* in the aforementioned cases.

On the other hand, there are situations where music can serve, and honorably so, as *just a sound track*. I'm speaking of the marine studies and maritime history programs that admittedly use music to "sweeten" the curricular content, especially for the beginning student. Although this technique is ubiquitous in our TV-Age educational environment, and at times thoroughly repugnant in its excess, there are several fine examples of "background" music serving as more than an ornament.

Floating in the childhood memories of many of us are the soundtracks of Disney nature films and Cousteau television specials. Unforgettable for many (especially those of us growing up in a post-World War II, Cold War America) is Richard Rodgers' dynamic score for the television series *Victory at Sea*—human drama and musical power blended into the ultimate naval history lecture.


Presently, on a smaller scale, but with hopefully far-reaching effects, we see the educational series *The Voyage of the Mimi*, a Bank Street College project in marine science and mathematics, and the satellite-network teaching efforts of Dr. Robert D. Ballard and the Jason Project (see *Oceanus* Vol. 33, No. 1) as examples of music being turned to account.

When it comes to video-packaged sea education, music is part of the rigging. If it is not there, or poorly done, the educational voyage might end well short of landfall.

*Oh, the times was hard and the wages low,
Leave her, Johnny, leave her!
But now once more ashore we'll go,
And it's time for us to leave her!
Leave her, Johnny, leave her,
Oh, leave her, Johnny, leave her!
For the voyage is done au' the winds don't blow,
Au' it's time for us to leave her!*

—Leave Her, Johnny, Leave Her—a traditional chantey

As it was for the ancient mariner, so it is for the casual museum

visitor, likewise for the serious student of marine and maritime subjects: there are certain things that help prepare us for what comes our way—things that open us, that intensify or temper our conscious reception, our ability to relate and to process. Learning and teaching is forever a fluid procedure of opening (to see), of closing (to focus), of expanding the receptive spirit, of sharpening and intensifying the interest, of conjuring or discovering things unbeknownst. For all who lead others to the window of a particular discipline, a certain body of knowledge and experience—for teachers—those things that help make the learner truly *ready to receive* are all-important. Music is one of those things—and a good one. 

Tom Goux is a teacher in the Falmouth, Massachusetts, school system. He is also a traveling troubadour of nautical music.

"Popularization"

It is usually found that only stuffy little men object to what is called 'popularization,' by which they mean writing with a clarity understandable to one not familiar with the tricks and codes of the cult. We have not known a single great scientist who could not discourse freely and interestingly with a child. Can it be that the haters of clarity have nothing to say, have observed nothing, have no clear picture of even their own fields?

**—John Steinbeck and Ed Ricketts
in *The Log from the Sea of Cortez***

The Changing Face of Maritime Education

by Geoff Motte

Maritime academies are diversifying their teaching efforts by offering new degree programs as a way of combatting slumping enrollment. In general, academies such as Massachusetts Maritime (MMA), Maine Maritime, and the U.S. Merchant Marine Academy at Kings Point, New York, are experiencing a drop in enrollment of about 20 percent. This drop is largely attributed to the shrinking number of overall high school students graduating across the nation.

The drop in enrollment comes at a time of significant demand for maritime academy graduates. In general, all academy cadets can expect to have two or three jobs to pick from when they graduate with starting salaries in excess of \$30,000 a year.

The Massachusetts Maritime Academy plans to offer degrees in facilities and plant engineering as well as marine environmental protection. The Maine Maritime Academy will be offering degrees in boat building and marina operations. The U.S. Merchant Marine Academy

at Kings Point does not plan to diversify at this time because the drop in enrollment actually helps their federal budget position.

A good ocean-going mariner must be provided with a sound base of relevant technical education for optimum blend with seagoing experience. It is appropriate that topics such as weather forecasting and practical seamanship be taught in concert with techniques for the safe operation of today's huge ULCCs (Ultra Large Crude Carriers), LNG (Liquified Natural Gas) carriers, and container ships.

Computer applications and knowledge of complex electronic shipboard systems are as important to efficient ship operations as are an understanding of the vagaries of the ocean environment and just plain good old-fashioned seamanship.

For a seagoing engineer, improvisational skills imparted via the machine shop go hand in glove with obtaining the highest possible operating efficiency from the 20,000-60,000 shaft horsepower (shp) slow-speed diesel or steam turbine propulsion plant that drives today's modern merchant ship.

To provide a responsive educational experience for future mariners, the faculty at the Massachusetts Maritime Academy is establishing a good foundation of general education in the freshman and sophomore years, gradually introducing the technical subjects as knowledge of mathematics, physical sciences, computers and ability to analyze and report increases. Extensive use of specialized engineering and navigation labs and training simulators follows in the junior and senior years.

To complement this approach to general and technical education, each cadet sails for at least three, two-month cruises onboard the Academy's primary laboratory—its training ship *Patriot State*. Highly experienced instructors, typically master mariners or chief engineers, are responsible for technical components of both the shoreside and seagoing training. Thus, a strong educational interaction is secured between classroom education and seagoing training. This feature is at the very heart of a successful preparatory education for seagoing officers.

Contrary to popular belief, there are tremendous job opportunities for well-trained mariners. Although the deep-sea fleet is greatly reduced from the Vietnam support days, many of its officers are close to retirement age. The Academy's Placement Office recently reported 80 job interviews in a single day. In the Spring, the Military Sealift Command's personnel hiring team was on campus for



Maritime cadets (above) in seamanship lab are taught techniques of block and tackle.

*The facilities
and plant
engineering
field is a
profession
that is rapidly
expanding.*

what the Placement Director refers to as a "million dollar day." MSC was interviewing for 20 seagoing positions having a total first year salary potential of about \$1 million.

The paramilitary nature of a cadet's daily life develops leadership and management skills valued by a wide range of employers. Engineering graduates confidently assume operational responsibilities for large seagoing engineering power plants and associated auxiliaries and systems. Deck graduates develop additional team management skills and an appreciation for the legal and environmental concerns of ship operation. Such skills are in demand ashore as well as at sea; and the Academy, through its Board of Trustees, is in the process of providing additional prospects for its graduates by broadening the curriculum.

The Academy, after carefully considering 10 new majors ranging from ocean engineering to applied oceanography and from maritime management to environmental engineering, has settled on two new majors. A Bachelor of Science program in facilities and plant engineering will be introduced this fall, to be followed hopefully by a similar program in marine environmental protection to commence in the fall of 1991.

The facilities and plant engineering program, which closely parallels an existing marine engineering major, emphasizes the operation and maintenance requirements of shoreside rather than seagoing power plants and associated systems. Approximately half the curriculum is devoted to fundamental courses in basic sciences, social science, mathematics, and the humanities.

The remaining courses are a combination of theoretical and applied engineering with special emphasis on "hands-on" engineering laboratory experience. The curriculum also includes four six-week cooperative sessions with industry to provide valuable on-the-job experience that may also lead to employment opportunities.

In lieu of these cooperative sessions, a student can choose to cruise on the *Patriot State* to gain direct operating experience with an 18,000-shp steam plant. A student in this major can commute from an off-campus residence or live in a campus dormitory as part of the corps of cadets. Almost a hundred graduates, mainly former seagoing engineers, are employed as operating engineers and managers of large engineering facilities and power plants within the region. This new program provides direct educational access to a profession that is rapidly expanding.

The proposed program in marine environmental protection, with courses in Law of the Sea and tanker operation and pollution control, more closely parallels the existing marine transportation major. This new major is presently in the planning stages and it is hoped that a cooperative approach will result between faculty and staff at MMA and those at the Woods Hole Oceanographic Institution (WHOI). We expect to deliver a unique and useful program answering some of the personnel needs in the field of environmen-

tal protection of the ocean and the coastal zone.

There is a growing need for knowledgeable individuals in the area of environmental law in order to provide for intelligent enforcement of legislation. The primary purpose of the proposed program is to provide the academic and technical exposure necessary to prepare professionals in this field.

In developing the curriculum, five principal areas of program structure have been considered:

1. Pollution Prevention
2. Fisheries and Species Protection
3. Waste Disposal
4. Coastal Wetlands
5. Ports and Harbors

The total program will combine a strong foundation of general education with a series of scientific and legal courses covering the field of environmental regulations. The program will be coordinated, for MMA, by Dr. Malcolm MacGregor and, for WHOI, by Dr. John Farrington (see introduction).

The face of maritime education is certainly changing. We anticipate considerable benefit to the future graduates of the Massachusetts Maritime Academy and hopefully to all concerned members of the ocean community.



A maritime cadet (above) in a machine shop learns to produce engine parts on a lathe.

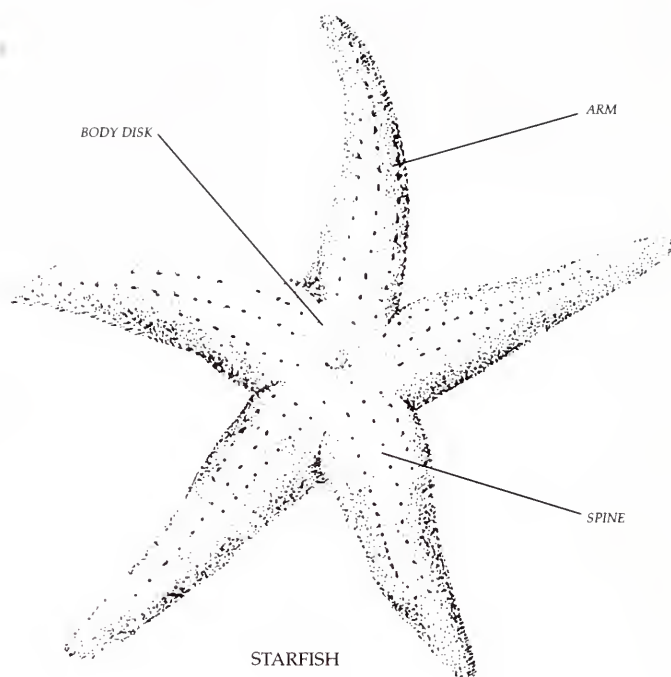
An instructor (below) shows maritime cadets how to operate a computer system similar to those used to run diesel engines.

Captain Geoff Motte is Vice President of Academic Affairs and Maritime Training at the Massachusetts Maritime Academy, Buzzards Bay.



Scientific Illiteracy

*We
Have Met
the Enemy and
He is Us*



by Joseph Levine

For the first several years of life, young children are endlessly fascinated with the world around them. Just try to stop kids from asking the questions scientists want to answer! Why do birds sing? Where does the tide go? What makes waves? Why can't we swim here anymore? Where do babies come from? Why did grandpa die?

How is it, then, that most people leave science classes either bored stiff or downright disgusted, many with a vow never to touch the stuff again?

It's because all the life in the "life sciences"—the

excitement, the feeling of discovery, the challenge, the drama, the relevance to daily life—are ruthlessly squeezed out by our educational process. Look over high school and college biology curricula, and you'll find precious few of the fascinating stories of “how we know what we know.” Very little (if any) time is spent on the process of science, and only a minimal effort is invested in relating concepts to students' daily lives. There is no time left at all to explain “why we do not know what we do not know,” or to discuss such related matters as the uses and limitations of data, uncertainty, and risk assessment. Instead, these courses concentrate on lists of Greek and Latin terms. The result? Courses that reward students' ability to memorize and deaden any real interest they might once have had.

According to polls conducted by organizations ranging from Gallup to the National Geographic Society, an astonishing 27 percent of Americans believe that the sun revolves around the earth, 40 percent cannot locate the Pacific Ocean on a map, and 47 percent do not believe in evolution.

Incidentally, lest we allow ourselves to be more complacent than we should be, note that half of those who *did* know that the earth revolves around the sun *did not* know how long it takes; more than 20 percent guessed 24 hours instead of 365.2 days.

Given this level of scientific illiteracy, is it any wonder that the public has no rational basis for evaluating complex issues, such as ocean dumping, coastal zone management, offshore drilling, loss of global biodiversity, acid rain, and ozone depletion?

How has this happened? Or—to phrase the question in a way that can prod us to action—what role has the academic community played in allowing this to happen?

No scientist or educator denies that the situation is serious. Yet thus far most academics refuse to make changes in either individual teaching style or institutional structure to address the problem.

It is easy for us to dig in our heels and insist that our educational methods *should* work today as they worked in the past. We can maintain that the techniques used to teach science majors *should* work for non-majors taking courses in elementary schools, high schools, and universities. We can insist that there is no reason why an intelligent, motivated student should not learn biology as we learned it.

It also is easy to implicate other factors and ignore our own role in making a bad situation worse. We can point our fingers at a host of problems that “explain” why a system that should be working is not. All these problems do, in fact, stand in the way of quality education, and the attitudes that perpetuate them must be changed. But the multidimensional nature of the problem does not exonerate us from accountability for our active roles in the tragedy.

I say this because after spending several years writing textbooks and working with public television and radio, I have come to a

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Scientists are addicted to specialized terminology and technical minutiae, essential to them, but irrelevant to the public at large.

difficult conclusion: despite the fact that some of the best ideas for improving education come from academic minds, by far the greatest resistance to innovation in teaching—both in the classroom and in society at large—comes from the same place.

Covering the entire relationship between the academic community and science education would take an entire book; John Burnham has done an excellent job in his jeremiad *How Superstition Won and Science Lost*. Here I'll be content if I can present a few of the pressing problems concerning high school and college textbooks, curricula, and teaching that stem directly from attitudes and practices within the academic community.

"That which we call a rose," quoth Juliet, "By any other name would smell as sweet." Ah, but if scientists could only feel the same way about their subject matter! To far too many academics, unless boldfaced scientific terms pepper most paragraphs, the subject has not been covered adequately. We are addicted to specialized terminology and technical minutiae, essential to us as professional scientists, but irrelevant to the public at large.

Here's a specific example of how this attitude affects a non-major's college text. My co-author and I were told by our editors that we had to double our coverage of plant structure and function to satisfy reviewers' comments. This "expanded coverage" consisted mainly of terms that neither my co-author—who studies the ultrastructure of photosynthetic membranes—nor I—an avocational botanist since high school—had used before writing the book. If we as professionals had never encountered these terms, why should non-scientists be forced to swallow them?

But lest I seem "zoo-partisan," animal biologists are hardly immune from criticism. Many embryologists, for example, seem unable to conceive of their subject matter divorced from its labyrinthine terminology. If all these terms were as important as "fertilization," "zygote," "placenta," or even "gastrulation," it would be one thing. But too many—"blastodisc" "blastomere" and "blastocoel" to mention just a few of the "B words"—are hardly of transcendental significance to the average citizen.

To check a hunch about how important such terms are in the context of an introductory course, I used my word processor to check unfamiliar words in a few chapters before and after we responded to reviewers' comments. Before revision roughly 75 percent of the terms we introduced were used more than once in a chapter, and 20 percent of them were used elsewhere in the text. Those terms were used repeatedly because they represented processes or structures that are integral to the way we look at the living world. But after revising those chapters—a process that sometimes doubled the number of terms—less than 40 percent were used more than once. Most were defined, used in a sentence once, and never touched again.

This is a widespread and serious problem. TheodoreSizer,

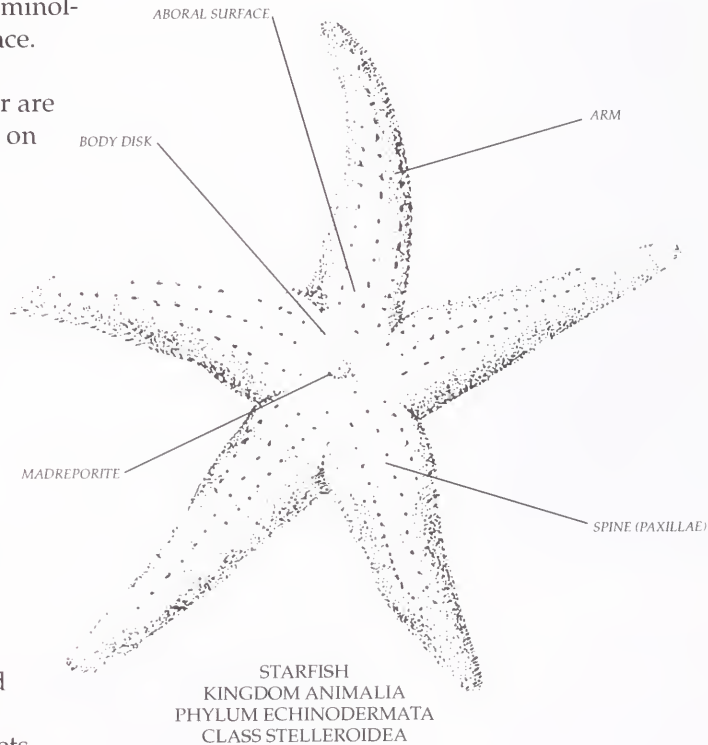
chair of the Education Department at Brown University, has estimated that the number of new words taught in high school biology courses exceeds the number taught in first-year French! Another educator estimated that students are expected to swallow between 2,400 and 3,000 new terms and symbols per science course. Given class periods of 55 minutes each, that translates into a new term roughly every two minutes. Small wonder that kids leave class viewing science as a foreign language, rather than a rational system of thought.

The problem is exacerbated by a cadre of teachers and professors—spread out over respected private and state high schools, universities, community and teachers’ colleges—who feel that terminology is, in fact, the way to teach science. Based on our publisher’s marketing studies, a distressingly large number are not prepared to teach courses based on concepts rather than definitions. At least three editors—all of whom have been biology teachers at some point themselves—assured me that “Most teachers do not want to teach concepts. That’s not only difficult, but tough to test in multiple choice format.”

This counterproductive educational approach among teachers and professors has serious negative effects on the textbook business, where we find a real catch-22 situation.

Even idealistic textbook adopters want full-color, glossy, handsomely-produced books with a dozen ancillaries (teacher and student guides, slide sets, test banks, and so on); the former because the showy format appeals to students and the latter because ancillaries make teachers’ jobs easier. Fine. But such books cost more than \$1.5 million to develop and launch, and publishers are not in business for pleasure. The size of that bottom line means that publishers must sell *lots* of books to recoup their outlay.

So, publishers send their manuscripts out for review to potential adopters. What comes back? Some very good reviews that point out errors, discuss outlook and content, propose treatment of important concepts that have been missed, and suggest better illustrations and examples. But there are a distressingly large number of narrow-minded, self-serving diatribes railing “I would



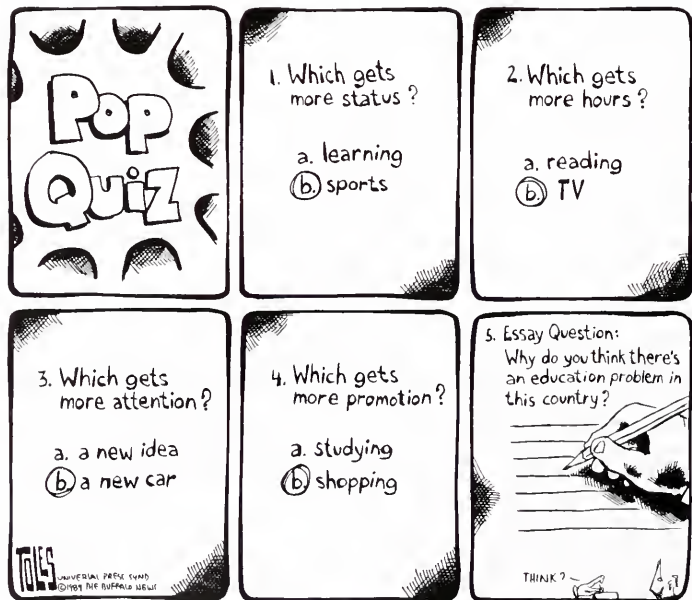
never buy this book unless you cover...(insert reviewer's favorite topic) and include the following terms..." Rarely do such people want books to address such questions as "How did Watson and Crick deduce DNA's structure?" or "What led Darwin to his theories on evolutionary change?"

Combine publishers' financial agendas with this input from the marketplace and you get the driving force for the evolution of textbooks; more facts, fewer pages spent developing concepts, and less storytelling throughout. Textbooks get so large that students will soon need fork lifts to carry them to class, but at the same time become less and less effective as real teaching tools.

Many blame publishers for this situation. "They should just put out a radically different book!" our colleagues cry. But although most editors I know want to do good work, the corporate hierarchy is in business to sell books, rather than to redefine educational priorities. "We can't afford to set trends," one editor told me recently. "We can only follow them. That's why most high school texts are roughly 10 years out of date." Welcome to the philosophy that has allowed Hondas to become America's most popular car, and encourages Hollywood to churn out "Friday the 13th Part 12" and "Rambo 6."

Given the problems within the academic community, it is not surprising that mass media are not doing the best job of educating or informing the public. There are a number of good science writers, primarily in print, but a few in broadcast media as well. Even the bright lights in the crowd, however, still have to deal with less enlightened gatekeepers. Face most of these with matters complex and conceptual in nature, and they react with handwaving. "Our (paper/magazine/news program) isn't the place for that," they cry. "We need straightforward news stories." In other words,

Textbooks, crammed with more and more facts and fewer concepts, are getting so large that students will soon need forklifts to carry them to class.

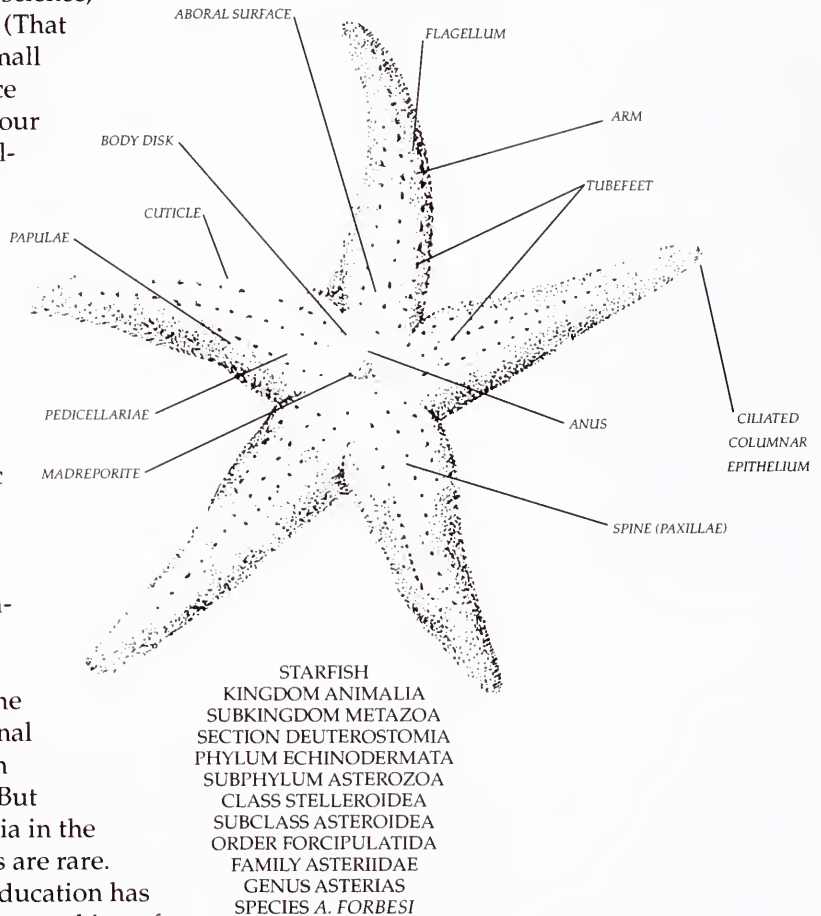


"Just the facts, ma'am." Forty years ago, an editor at *The New York Times*, after killing a story on cosmic rays, explained his action by telling the reporter "The publisher doesn't like cosmic rays, and neither do I. Furthermore, let me tell you, I do not believe in atoms and have but slight faith in molecules."

You wouldn't want to know how many similar—if slightly updated—pronouncements I've heard from well-placed magazine editors and producers of science television programs. Many of these people have a real love/hate relationship, not only with science, but with scientists as well. (That relationship stems, in no small part, from the sort of science education they received at our hands.) Reacting as journalists, the majority of them see scientific debates—which we view as the heart and soul of our disciplines—as either egotistical gamesmanship or spineless equivocation.

The result of this jaundiced view of scientific discourse is the endless flood of "tidbit" or "gee whiz" science news that overwhelms serious, educational science journalism. There are exceptions, of course, especially among the best newspapers, on National Public Radio, and at certain public television stations. But when looking at mass media in the aggregate, these exceptions are rare.

In summary, biology education has been slipping away from the teaching of science toward the recitation of "facts," a trend that has serious repercussions. For when we teach isolated facts freed from the process that produces them, we abandon science as "A way of knowing," as a series of rational techniques for observing and understanding the world around us. We may tell our students that science is a process. We may tell them that science is vital in the modern world. But we should understand why they do not get that message if we bombard them with lists of organisms, trophic levels, chemical cycles, and metabolic pathways.



The resulting public reaction to issues concerning science is predictable. "When men cannot observe," noted author Naipaul, "they do not have ideas, they have obsessions." As chillingly documented by Burnham and verified by recent polls, a growing number of people in this country have no *understanding* of science whatsoever; they either *believe* in science or they do not *believe* in science, just as they either believe in ghosts or do not believe in ghosts. What our approach to science education does, therefore, is to set our public up to treat science as a belief system—not unlike either religion or superstition—rather than as a way of interacting with the world in a rational manner.

This, in turn, leaves us a step away from another predicament. If science is set up in peoples' minds as a belief system, the door is left open for those who insist that religion (for example, creationism) must be taught as well, because there is no objective way to choose between two equally arbitrary systems of belief! Unfortunately, if you compare the way biology is usually taught to non-majors with a typical catechism class, you will find more similarities than differences in teaching methods.

What can each of us do to work our way out of this mess? First and foremost, we must understand that non-scientists—both school kids and adults—have a different mindset about science than scientists do. That mindset isn't inferior to the scientific mindset in any way, but it is different.

I would never advocate that we try to change who we are as scientists or the way we do science. That would be both hypocritical and self-defeating. But I do argue that in order for us to communicate with the public—both in and out of the classroom—we must "translate" information in a way that bridges the gap between our world view and that of non-scientists. We could retreat into the argument that an intelligent public should be able to meet us on our own turf. Unfortunately, here and now, that strategy isn't working. As educators we shouldn't be asking "How do we get people to do things our way?" but "How can we change our approach to reach more people with our message?"

Second, many more of us must make a commitment to improve our teaching in as many ways as possible. We must improve our ability to communicate the essence of inquiry to students whose interest in science has not been encouraged. There are many ways to do this, none of which require us to take courses in schools of education. Courses in effective writing and speaking would help, as would increased and more active interaction with members of our community who are outstanding teachers, and more constructive interaction with qualified members of the media world.

On another level, we must work within and among departments to present courses that highlight the way science works and the impact of science on individuals, on society, and on the biosphere. Some of these courses must be interdisciplinary. It is

hard—if not impossible—to engage in a meaningful discussion of global ecology without involving more economic and political theory than most biologists are comfortable with. It is equally difficult to discuss organ transplants or screening for genetic diseases without crossing the boundary between biomedicine and ethics. But because these are precisely the sorts of issues in which students are most interested, we've got to call in qualified colleagues as guest lecturers or share the lectern with economists or ethicists.

Finally, because accomplishing these goals will be difficult and time-consuming, we must force so-called “institutions of higher learning” to really place teaching on their priority list. For as we all know, despite lip service to quality teaching, most colleges and universities (quoting a National Science Foundation [NSF] report) perpetuate “a value system in which research productivity and grantsmanship are viewed as of primary importance, while teaching and advising undergraduates are viewed as secondary in importance and are generally unrewarded.” Until these institutions include quality teaching among criteria for tenure and promotion, junior faculty will be unable to commit the time and effort, senior faculty will be unwilling to do so, and graduate students will see that refining teaching skills isn't worth the time it takes.

There are some encouraging signs. NSF has offered new initiatives that include a grant program to improve introductory level science teaching. This program, *Undergraduate Curriculum and Course Development in Engineering, Mathematics, and the Sciences: Introductory Level*, awards grants competitively in the standard manner, includes summer salary and overhead, and encourages multi-disciplinary and interdisciplinary approaches. This may be the first step in placing teaching on a par with research, for it allows faculty interested in teaching to bring money and prestige to their institutions as their research-oriented colleagues do.

Joseph Levine is founder of Boston Science Communications, Inc., which produces educational films and products. Author of two popular books, many magazine articles, and co-author of two biology textbooks, he earned a Ph.D. at Harvard, and taught for five years at Boston College.

*In a
meaningful
discussion of
global
ecology,
biologists
must share
the lectern
with
economists
and political
scientists.*

This article has been adapted from one that originally appeared in the Marine Biological Laboratory publication MBL Science, Spring 1990.

LETTERS

To the Editor:

I read with great interest the article "Changing Climate and the Pacific" (Winter 1989/90, Vol. 32, No. 4, pp. 71-73) because the results of at least two decades of archaeological work on both Pacific Islands and continental areas have suggested that past dynamics of holocene geomorphological change, subsidence, uplift and eustatic sea level change have been substantial in altering the landscapes that we see in the Pacific today.

On Upolu in Western Samoa, for instance, the earliest archaeological site yet discovered, at Mulifanua, lies 110 m. off shore from the present ferry berth and is encrusted with sheet coral under 2 meters of water. Tongan sites on the other side of the Tonga Trench are often inland behind former standlines that are now a considerable distance from the shore. At Nuiatoputapu in the Tongan Archipelago, Pat Kirch from UC-Berkeley has shown that land area almost doubles during 3000 years of human settlement, while in the Hawaiian Islands there has been considerable progradation at Kawainui Swamp, Oahu and on the leeward side of Molokai. On Touhou islet on Kapingamarangi atoll virtually the total landmass of 96,000 m² was culturally redeposited, suggesting to the excavators that Touhou is an artificial islet like some of those off the coast of Malaita in the Solomons.

The whole suggests that there are many factors involved in apparent sea level changes, but shows definitively that the history of human settlement in the form of archaeological evidence should come into play at some point as witnesses to these dynamics in the past. The past offers us lessons that we can not ignore in our projections into the future.

Thomas J. Riley
Head

Department of Anthropology
Univ. of Illinois at Urbana-Champaign

To the Editor:

Henry Stommel's "Island Fancies on Fleets of Neutrally-Buoyant Floats" (Winter, 1989/90, Vol. 32, No. 4, pp 93-96) is a delightful continuation of the work in this field dating from the 1960s. In 1967, I was invited to Woods Hole to work with Douglas Webb and others on my current-following gadget, the SWIB, or SHALLOW WATER ISOBARIC BUOY. The SWIB moved up and down in response to density differences. SWIB used carbon dioxide cylinders to change the volume of a piston thus increasing or decreasing the density of the instrument. This caused the device to sink or rise.

In the summer of 1966, I gave a talk on SWIBS in Moscow where I discussed isobaric buoys with Alvin Vine, John Isaacs, and other distinguished ocean mavens. Work on the SWIB was followed by proposals for free floating OSCULATING BUOYS, neutrally buoyant floats that would oscillate between a fixed isobaric level and the surface. In the *Journal of Ocean Technology* (Vol. 2 No. 1, 1967) we suggested that "A buoy could be programmed to descend to particular depths, take readings as it drifts with the currents, and then rise to the surface to transmit its data..." OSCULATING BUOYS would, when desired, rise to kiss the surface, hence the name.

Stommel seems to be proposing OSCULATING BUOYS with a self-powered directional capability. Though how his gadgets could draw their power from the "stratification of the ocean" is unclear to me. Well why not?

The SWIB and OSCULATING BUOY concepts were in advance of 1960s thinking. I am pleased to see Stommel's floating buoy dreams in print. If mankind does not blow itself up someday they will be realized.

Cy A. Adler
New York, NY

(Editor's Note: Adler is author of *Ecological Fantasies—Death From Falling Watermelons.*)

BOOK REVIEWS

3 Ballard Books Due to be Published

Determined to leave no adventure unturned, Dr. Robert D. Ballard, senior scientist and head of the Deep Submergence Laboratory at the Woods Hole Oceanographic Institution, and likewise a writer, private entrepreneur, television documentary host, and spokesman for creative science education, is testing the waters of thriller fiction writing.

Ballard is best known for his ocean frontier explorations through such efforts as the Jason Project (see *Oceanus*, Vol. 33, No. 1). He and his oceanographic team have taken television and telepresence viewers on journeys to subsea mountain ranges and bottomlands at a depth of 16,000 feet via underwater manned and unmanned vehicles named *Alvin*, *Argo*, *Jason* and *Medea* in search of historical sunken ships—*The Titanic*, *Bismarck*, *Isis*, *Hamilton*, and *Scourge*—in the waters of the Atlantic, Mediterranean, and Lake Ontario.

Now Ballard is exploring the depths of his own imagination, culling his journals, and ships' logs to create with New York writer, Tony Chiu, his first spy thriller for publication in the summer of 1991.

"The challenge to me," said Ballard, "was could I write an exciting fictional novel that was technically accurate and without sex and violence."

Described by Ballard as "unique in that it is technically impeccable," the novel's story is built around the actual loss in the late 1960s of an Israeli submarine called *Dakar*, which is Hebrew for shark. Purchased from England and lost on its maiden voyage somewhere in the Mediterranean, the sub's mission has always been a mystery.

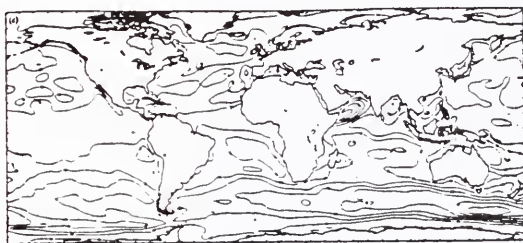
Set in a 1987 to 1989 time frame, interwoven with actual world events then, the saga entails three central characters; a woman Navy lieutenant, a male oceanographer, and a retired submarine officer. The tale hinges on America's concern about nuclear proliferation.

In addition, coming out October, 1990,

are two books recently completed by Ballard and a writing team at Madison Press of Toronto, Canada, publishers of the books. One is a children's book entitled *The Wreck of the Isis*, and the second, which is geared toward an adult audience, is *The Bismarck*.

Based on 1989's Jason Project in the Mediterranean, *The Wreck of the Isis* consists of two stories told in tandem. One story is a fictionalized version of the ship's journey from the time it set sail from Carthage in 355 A.D. to the moment of its sinking in stormy Mediterranean seas. It is a tale told through the eyes of a young boy named Antonius, whose father owned *Isis*, and it leads to the ship's sinking, with Antonius being rescued.

Alternating chapters relate the Jason Project's discovery of *Isis* 1,545 years later. Colorful and artistic throughout, the book features photographs and original artwork.



Tracers in the Ocean

Edited by H. Charnock, J. E. Lovelock, P. S. Liss, and M. Whitfield

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In its epilogue, Ballard and his team of explorers explain what they learned from their studies then, and what the Jason Project continues to achieve educationally with thousands of students.

The *Bismarck* book is designed with a format similar to Ballard's past books, an encompassing epic tale of history, tragedy, and rediscovery (see *Oceanus*, Vol. 32, No. 3). Highlights include extensive original artwork commissioned from artists in the United States, England, Canada, and West Germany.

Featured are captivating paintings by Los Angeles artist Ken Marschall, who brought Ballard's book, *The Titanic*, vividly to life, and historic World War II photos researched from European naval archives. The book's text was likewise a team effort among researchers, historical experts, writers and editors working with Ballard.

Both books are significant to Ballard not only because they comprise all that he has learned about their subjects, but because they are dedicated to his first son, Todd Alan Ballard, who shared the experiences with him, and who one month after their completion died in a car accident.

When asked about the increasing public

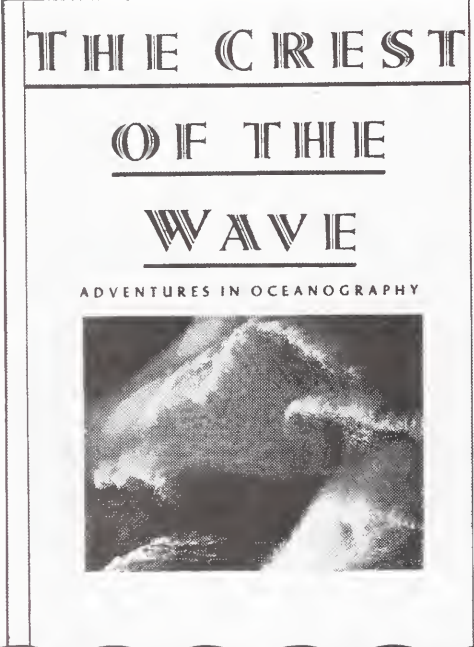
curiosity of whether Dirk Pitt, hero of Clive Cussler's science fiction adventure novel, *Raise The Titanic*, and subsequent adventure novels, was drawn from his personality, Ballard reeled with laughter.

"Oh, I don't know," said Ballard. "I've been called Carl Sagan with gills, the young Cousteau, Indiana Jones, and now I'm being called Dirk Pitt. But, I'm just Bob Ballard, that's all."

Available in bookstores in October, *The Bismarck* will be a hardcover publication priced at \$35.00. *The Wreck of the Isis* will be available in both hard and soft cover for \$15.95 and \$6.95, respectively.

—Kathy Sharp Frisbee
Editorial Assistant
Oceanus magazine

Woods Hole Oceanographic Institution




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Guide to the Marine Isopod Crustaceans of the Caribbean, by Brian Kensley and Marilyn Schotte; 1989; Smithsonian Institution Press, Washington, DC; 308 pp. - \$35.00.

North Atlantic Studies: Whaling Communities, edited by Elisabeth Vestergaard; 1990; Centre for North Atlantic Studies, Aarhus University Press, Denmark; 220 pp. - 240 DKK.

Orcas of the Gulf: A Natural History, by Gerard Gormley; 1990; Sierra Club, San Francisco, CA; 189 pp. + v - \$10.95.

The Pinnipeds: Seals, Sea Lions, and Walruses, by Marianne Riedman; 1990; University of California Press, Berkeley, CA; 439 pp. + xxiv - \$29.95.

ENVIRONMENT

Carbon Dioxide and Global Change: Earth in Transition, by Sherwood B. Idso; 1989; IBR Press, Tempe, AZ; 292 pp. + iv. - \$19.95.

Common Heritage or Common Burden? : The United States Position on the Development of a Regime for Deep Sea-Bed Mining in the Law of the Sea Convention, by Markus G. Schmidt; 1990; Oxford University Press, Cary, NC; 317 pp. + v - \$72.00.

Design for a Livable Planet: How You Can Help Clean Up the Environment, by Jon Naar; 1990; Harper & Row, New York, NY; 338 pp. + x - \$12.95.

Fire and Ice: The Greenhouse Effect, Ozone Depletion & Nuclear Winter, by David E. Fisher; Harper & Row, New York, NY; 232 pp. - \$19.95.

The Next One Hundred Years: Shaping the Fate of Our Living Earth, by Jonathan Weiner; 1990; Bantam Books, New York, NY; 312 pp. - \$19.95.

World Resources: A Guide to the Global Environment, Report by The World Resources Institute; 1990; Oxford University Press, New York, NY; 367 pp. + viii - \$29.95.

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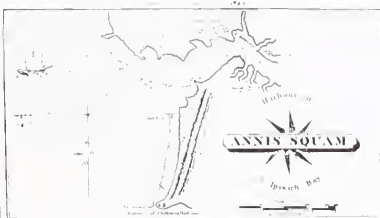
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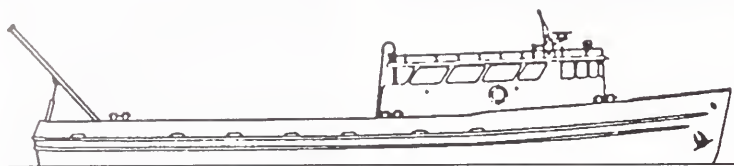
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The Yosemite, photos by Galen Rowell, narrative by John Muir; 1989; Yolla Bolly Press, Covelo, CA; 221 pp. - \$40.00.

Silver: The Life Story of an Atlantic Salmon, by Roderick L. Haig-Brown; 1989; Lyons & Burford, New York, NY; 91 pp. - \$15.95.

Winds of Change: Women in Northwest Commercial Fishing, by Charlene J. Allison, Sue-Ellen Jacobs, and Mary A. Porter; 1990; University of Washington Press, Seattle, WA; 174 pp. + xviii - \$25.00.

FISHERIES

Hawaiian Reef Animals, Revised Edition, by Edmund Hobson and E.H. Chave; 1990; University of Hawaii Press, Honolulu, HI; 137 pp. + xiii - \$19.95.

Light and Life In The Sea, edited by Peter J. Herring, Anthony K. Campbell, Michael Whitfield and Linda Maddock; 1990; Cambridge University Press, NY; 298 pp + xxiv - \$59.60.

Management of World Fisheries: Implications of Extended Coastal State Jurisdiction, edited by Edward L. Miles; Institute for Public Policy and Management and Institute for Marine Science of the University of Washington, Seattle, WA; 318 pp. + xiv - \$30.00.

MARINE POLICY

In the Wake of the Exxon Valdez: The Devastating Impact of the Alaska Oil Spill, by Art Davidson; 1990; The Sierra Club, San Francisco, CA; 315 pp. + xi - \$19.95.

Managing Troubled Waters: The Role of Environmental Monitoring, edited by Sheila A. Mulvihill; 1990; National Academy Press, Washington, DC; 125 pp. + x - \$24.50.

The Ocean in Human Affairs, edited by S. Fred Singer; 1990; International Conference on the Unity of the Sciences, New York, NY; 374 pp. - \$34.95.

Oceans of Wealth?, edited by K.R. McKinnon; 1989; Australian Government Publishing Service, Canberra, Australia; 188 pp. + xx - \$29.95.

OCEANOGRAPHY

Antarctic Sector of the Pacific, edited by G.P. Glasby; 1990; Elsevier Science Publishers B.V., Amsterdam, The Netherlands; 324 pp. + xv - \$97.50.

Developments in Hydrobiology: Sediment/Water Interactions IV, edited by P.G. Sly and B.T. Hart; 1989; Kluwer Academic Publishers, Norwell, MA; 533 pp. - \$235.00.

New Explorers: Women in Antarctica, by B. Land; 1981; Dodd Mead, New York, NY; 224 pp. - \$9.95.

Oceanography 1988/Proceedings of the Joint Oceanographic Assemblies, edited by Agustin Ayala-Castanares, Warren Wooster, and Alejandro Yanez-Arancibia, Universidad Nacional Autonoma de Mexico, Consejo Nacional De Ciencia Y Tecnologia, and UNESCO.

Year 2000 Challenges for Marine Science Training and Education Worldwide, UNESCO Reports in Marine Science; 1988; United Nations Educational, Scientific and Cultural Organization, Paris, France.

Women on the Ice: A History of Women in the Far South, by E. Chipman; 1986; Melbourne University Press, Melbourne, Australia; 224 pp. - \$28.50.

REFERENCE

The Emperor's New Mind: Concerning Computers, Minds, and The Laws of Physics, by Roger Penrose; 1989; Oxford University Press, New York, NY; 449 pp. + v - \$24.95.

Attention

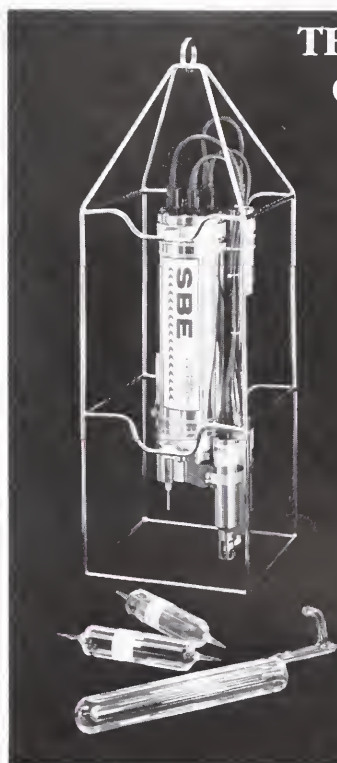
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Photography and the Art of Seeing, by Freeman Patterson; 1989; Sierra Club Books, San Francisco, CA; 156 pp. - \$17.95.

Photography of Natural Things, by Freeman Patterson; 1989; Sierra Club Books, San Francisco, CA; 168 pp. - \$17.95.

The Threat and the Glory: Reflections on Science and Scientists, by Peter Medawar; 1990; Harper Collins Publishers, New York, NY; 227 pp. - \$22.50.

Port Engineering, Volume 1: Harbor Planning, Breakwaters, and Marine Terminals, by Per Bruun; 1989; Gulf Publishing, Houston, TX; 1461 pp. + xxvi - \$195.00.

Port Engineering, Volume 2: Harbor Transportation, Fishing Ports, Sediment Transport, Geomorphology, Inlets, and Dredging, by Per Bruun; 1990; Gulf Publishing Company, Houston, TX; 1146 pp. - \$145.00.

State of the World 1990, edited by Linda Starke; 1990; W.W. Norton & Company, New York, NY; 253 pp. + xvi - \$28.95.

Traveler's Guide to the Galápagos Islands, by Barry Boyce; 1990; Galápagos Travel, San Jose, CA; 227 pp + vi; \$14.25.

Turbulent Mirror: An Illustrated Guide to Chaos Theory and the Science of Wholeness, by John Briggs and E.F. David Peat; 1989; Harper & Row Publishers, New York, NY; 203 pp. + x - \$12.95.

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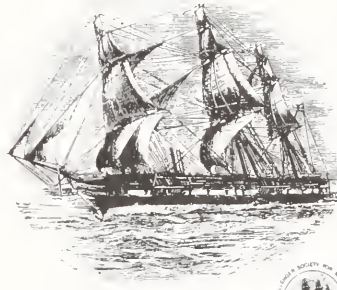
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